MISC-Army

LEVEL II

CONTRACT NO DAEA 18-68-C-0004

USAIB PROJECT NO 3319

AD A075710

INFANTRY WEAPONS TEST METHODOLOGY STUDY

FINAL REPORT

VOLUME II

ANTITANK WEAPONS TEST METHODOLOGY

Final rept.

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17 January 1972

UNITED STATES ARMY INFANTRY BOARD
FORT BENNING, GEORGIA 31905

DISCLAIMER NOTICE

DEPARTMENT OF THE ARMY
ARI FIELD UNIT, BENNING
U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
P.O. BOX 2086, FORT BENNING, GEORGIA 31905

PERI-IJ

8 August 1979

SUBJECT: Shipment of Documents

Defense Documentation Center
Cameron Station
Alexandria, VA 22314
ATTN: Selection & Cataloging

The Documents in these shipments are approved for public release. The distribution is unlimited.

FOR THE CHIEF:

ALEXANDER NICOLINI
Major, Infantry
R&D Coordinator

CONTRACT NO DAEA 18-68-C-0004

USAIB PROJECT NO 3319

INFANTRY WEAPONS TEST METHODOLOGY STUDY

FINAL REPORT

VOLUME II

ANTITANK WEAPONS TEST METHODOLOGY

17 January 1972

UNITED STATES ARMY INFANTRY BOARD
FORT BENNING, GEORGIA 31905

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION AND SCOPE

a. Introduction - Volume II of the Infantry Weapons Methodology Study summarizes findings concerning the testing of antitank weapon systems. Volume II is accompanied by four appendices which are attached to this document. Volume I, published earlier, was oriented towards small arms test methodology. Later volumes will be published containing summaries of progress in the areas of 40-mm grenade launchers, machine guns, and indirect fire test methodology.

b. Scope - The first four years of the methodology study have been oriented primarily toward small arms test methodology. However, some investigations into test methodology for other Infantry weapon systems have been attempted. These efforts have been oriented toward scoring systems and target vehicles. The assumption was that any improvement in test methodology, particularly with reference to antitank (AT) weapons, would include investigation into improved scoring systems and reliable target carriers. The balance of this report is based primarily on an understanding of the factors that influence small arms operational testing and the application, where possible, of this understanding to AT weapon test methodology. This report attempts to answer the following four objectives with respect to AT test methodology:

(1) Determine those factors influencing the evaluation of Infantry weapons under realistic combat environment.

(2) Develop techniques and methods to measure critical factors influencing weapon evaluation.

(3) Isolate those factors which are subjective, involving judgement and experience, and which are not amenable to measurement from those which are, and establish the relative importance of each; and

(4) Develop automated test facilities which will permit operational testing with a minimum of maintenance and technical support.

2. BACKGROUND

a. Purpose of the Report - The purpose of this report is to summarize, under a single cover, efforts and findings concerning AT test methodology which has been performed with contractual support provided by the Mellonics Division of Litton Industries, Inc., Contract Number 18-68-C-0004.

b. Chronology - The major events concerning the AT Methodology study appear below. Unless otherwise mentioned, reference to each major event will be found in the monthly progress reports, which appear in Appendix XI, Volume I.

Jul 66 - Directive (Volume I, Appendix I)

Aug 67 - Contractual Support Begins

Oct 67 - Evaluation of Moving Man Target System

Oct 67 - Antenna Radiation Pattern Test for Moving Target Data Link

Jan 68 - Tone Control Added to Radio Data Link

Mar 68 - Initial Design of Moving Man Target, MTV-200

Jan 69 - Contract for First MTV-200

Jun 69 - Survey of Existing AT Targets

Aug 69 - Technical Memorandum - Honeycomb Antitank Target Hit Skin (Appendix IV)

Sep 69 - Technical Support for LAW Test

Jan 70 - Project Analysis for AT Test Range (Appendix I)

Jan 70 - Technical Data Package for AT Moving Target

Jul 70 - Antitank Project Review (Appendix II)

Sep 70 - Contract Let for AT Target Carriers

Nov 70 - Project Analysis - Antitank Weapons Test Methodology (Appendix III)

Nov 70 - Support for FLASH

Dec 70 - MTV-300 AT Target Delivered and Tested

Jan 71 - Improved Data Link Developed

Jan 71 - Technical Data Package for AT Data Link Completed

Apr 71 - MTV-400 Delivered and Tested

3. EXECUTIVE SUMMARY

As indicated by the chronology of events, the primary effort to date has been in problem definition, data link, hit skin development, and in the design and construction of moving target systems.

The problem definition phase began with the initial project analysis which defined test facility parameters. This was followed by the project review which analyzed combat tasks and actions in terms of dependent variables. The third publication, Project Analysis - Antitank Test Methodology, attempted to define influencing variables that are a part of operational testing of AT weapon systems; the result of this effort is discussed under Technical Objectives 1 thru 3.

The result of the initial effort in examining AT scoring systems was the adaptation of a material formerly used for aerial targets to AT targets. The material is light, strong, honeycomb, resin impregnated, cardboard material. The honeycomb construction permits the material to absorb severe punishment such as large holes with a minimum loss of rigidity. By applying foil layers to the exterior surfaces, an electronic scoring system can be used. Early tests in 1969 showed that the target material could score both the spotting round and the main round of a 106-mm recoilless rifle. Heretofore, the characteristics of the .50-cal and 106-mm rounds were such that they previously could not be scored with the same target material. The strength and ruggedness of this material makes this possible. The development and detailed description of this material is recorded in a technical memorandum, Appendix IV.

The moving target data link available for use on AT targets is the same unit that is used on the moving man target.

Lastly, two new antitank target carrier systems have been developed. The moving target vehicle-300 (MTV-300) is capable of carrying a 7½' x 16' silhouette at controlled speeds from 10 to 25 miles per hour. Precise replications to within 5-percent speed variation (1 mile per hour at 20 miles per hour) is within the capabilities of the system. The target system was patterned after the MTV-200 target which was designed for the small arms test facilities. In addition, a high speed AT target (MTV-400) capable of reliably controlled speeds from 25 to 50 miles per hour was designed and constructed. These two units add significantly to the United States Army Infantry Board (USAIB) AT weapon testing capability.

All of the above developments have been complicated by the varying characteristics of AT weapons. Automatic scoring of both hits and near misses, as well as testing techniques and methodology have been difficult to accomplish. The muzzle blast, flight time, launch characteristics, weight, projectile size and configuration vary severely from conventional systems (such as the recoilless rifle family) to missile systems (such as the TOW, ENTAC, SS-11, DRAGON, SHILLELAGH). Also, there is a variety of warheads to consider: inert, sabot, shaped charged. These varying characteristics make instrumentation in terms of automatic scoring extremely difficult. The extreme ranges of these weapons also require significant sums of money for data links, either radio or wire. Consequently, the need for automation has been critically reviewed. The conclusions appear below:

(a) Visual scoring will be used for normal testing since AT weapons normally have slow rates of fire and large terminal effects (holes in targets). Automatic scoring with the honeycomb hit sensitive target material with the Joanell signal conditioning unit will be used for special systems requiring automatic scoring, such as the 50-cal spotting round or the VULCAN in an AT role. Stationary targets will use coaxial cable data links, and moving targets will use the transmitter developed for use on the MTV-200. Recording can be done either by oscillograph or ADPE.

(b) Miss distance, if required, for hypersonic projectiles will be collected with the current time difference system; subsonic missiles will use photographic methods. High speed cameras with telescopic lenses can be used or cinephototheodolites can be borrowed from other agencies and used. Other methods of scoring near misses (e.g. radar, light screen, radio active projectile) were considered; these methods were rejected because of implementation costs and technical complexity.

(c) Current moving and stationary target carriers are adequate and represent the state of the art in terms of reliability and performance. Possible future improvements include the addition of 3-dimendional targets.

The knowledge gained from the operational evaluation of small arms and antiaircraft weapon systems indicates that other factors must be considered in the evaluation of AT weapon systems. These factors include crew proficiency, crew motivation, terrain, and means of weapon employment. These variables specifically influencing the operational testing of AT weapon systems are discussed in paragraph 4, Technical Objectives.

Since there was considerable carry-over of methodology and instrumentation development from other parts of the

methodology study, it is difficult to estimate the manpower that has been expended in support of the AT portion of the study. Field testing of the hit skin has consumed a total of 1 man-month of time, as has laboratory development of special purpose signal condition to support field testing. The preparation of the project review and two project analyses required approximately 5 man-months. Development of the moving target system required approximately 8 man-months of contractor time, which was devoted primarily to feasibility studies determining plausible routes of approach, e.g., hydraulic powered mechanisms, radio control systems, mechanical lifting apparatus. Excluding carry-over knowledge and experience from the small arms methodology study, approximately 15 man-months of the current program has been oriented directly toward the antitank methodology study.

The initial project analysis in Appendix I contains a glossary, references, and a PERT chart showing the major tasks associated with AT methodology. The chart represents the original schedule of events and therefore includes a field experiment as part of the methodology study. This step was eliminated in order to expand the Infantry Weapons Methodology Study into other specific areas such as machine gun and 40-mm grenade methodology. Lessons learned during the operational evaluation of small arms concerning factors influencing operational testing have been applied to the AT methodology study in lieu of the formal field experiment. The results of this analysis appear in sections 4 through 6.

4. TECHNICAL OBJECTIVES

The support contract for the Infantry Board Methodology study specifically states that four technical objectives will be focused on during the study. The efforts and findings in pursuing each of these objectives appear in the appropriate paragraphs.

a. Technical Objective 1.

(1) Introduction - The determination of factors influencing the evaluation of antitank weapons in a realistic combat environment is discussed in the project review and the project analyses. The second project analysis, Antitank Weapons Test Methodology (App III), specifically addresses the major factors influencing operational testing. No field experiment was run to test scientifically the assumptions outlined in that analysis. However, field experimentation oriented to the operational testing of other weapon systems plus previous work in the AT area at

other agencies testify that the following factors are indeed important in AT weapon evaluations:

(a) Selection of Measures of Effectiveness

(b) Human Factors - Sampling, Motivation, and Stress

(c) Training

(d) Terrain

(e) Threat

(f) Vulnerability

Each of these critical factors should be an integral part of operational testing.

(2) Weapon Evaluation - USAIB personnel reveiwed the actions of a wide variety of AT weapon systems. By combining actions with similar characteristics, the 25 combat actions considered were reduced to a representative list of seven:

Deliberate Defense

Hasty Defense

Retrograde Operations

Fire and Movement

Tank Killer Operations

Combat in Cities

Advance to Contact

Next, these actions were analyzed in terms of individual tasks. Using the task/action table on page C-2 in the Infantry Weapons Antitank Methodology Review (Appendix II), a list of tasks was derived. These tasks must be performed to complete the actions mentioned above:

Long Range Aimed Fire

Medium Range Aimed Fire

Short Range Aimed Fire

Rapid Movement - Rapid Fire

Rapid Reaction to Suitable Targets

Although other tasks are discussed, the five shown here are representative of the tasks which must be done by the weapon crew to perform the seven combat actions. These are the critical tasks that must be considered during operational service test.

The next step was to select or develop measures of effectiveness (MOE) and test techniques which will provide information on the weapon system's capability to perform these basic combat tasks. These MOE and techniques are described under objective 2.

(3) Human Factors - There are many human factors that must be considered in operational testing. The basic critical factors are soldier selection, motivation, and stress.

Statistical considerations dictate that care should be used in selecting test soldiers for participation in operational service testing. The objective of the service test is to predict the weapon system performance levels that can be expected under combat conditions. The goal of the service test is to select the most effective weapon system for use in the combat environment. Generalization of results from the test situation to the combat situation is a necessary step and the validity of this generalization is directly dependent on the fact that factors influencing the combat performance of a weapon system must be present during the service test. One of the most important factors is a representative sample of test soldiers. The use of soldiers that are atypical, or the use of technical representatives during the measurement of performance under test conditions, will not permit generalization of results to the combat environment. The use of sample sizes that are too small will result in the inability to reach statistically conclusive results.

Once a representative sample has been selected from the parent population a second human characteristic must be considered. The test soldier must be adequately motivated to produce a level of performance that could normally be expected under combat conditions. Again, without adequate motivation generalization of results becomes extremely risky.

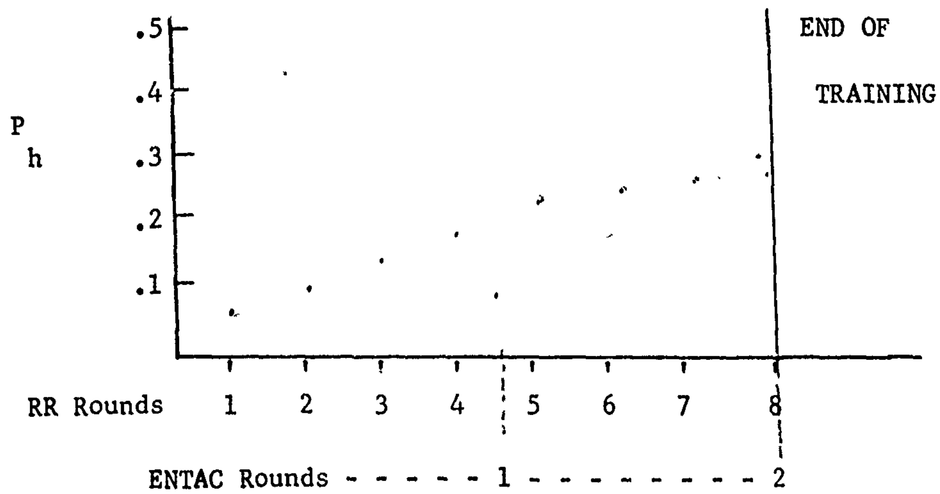
The third human factor is combat stress. This factor is the most difficult and possibly the most important human factor in the combat environment. The effects of stress on behavior have been shown to produce results that vary widely from individual to individual. Adequate consideration of this factor in the service test situation becomes extremely difficult and yet its importance cannot be denied. Rifles found on Civil War battlefields were discovered to contain repeated charges of powder and ball.

This indicated that the soldiers repeatedly loaded and fired their weapons during the heat of combat, but the weapons actually failed to discharge. This shows that the soldier performed as trained, but did not realize that he actually was not firing.

Methods and techniques for consideration of these factors are discussed under objective 2.

(4) Training - This important factor is a big problem in operational testing, especially when test weapons are of a type that fire comparatively few rounds. The importance of training can be illustrated from findings concerning the small arms portion of the methodology study. In 1965, attack experiment I was completed on the newly developed attack facility. Although objective methods were used to balance groups of test soldiers on their marksmanship ability and special training sessions were held, one rifle was decidedly superior. The superior rifle was the inventory rifle on which test soldiers received basic training, advanced Infantry training, and annual qualification. In 1968, a second study was run on the newly developed quickfire facility. By this time training on the two test rifles had equalized. The rifles were very close in terms of performance. In 1970, Defense Experiment I was completed using the same weapons with balanced groups of test soldiers and special training sessions. Again, the rifle in current usage throughout the Army tested as the superior weapon. However, it was the inferior rifle in the initial test. Test soldiers were quizzed to determine the extent to which they were familiar with the two rifles. Of the 72 test soldiers, only one had fired the M14 rifle in combat prior to the defense experimentation; 56 of the test soldiers used the M16 in combat. These results show that training is a significant source of bias against a new weapon system.

How do these findings relate to AT weapon evaluation? The answer is significantly, perhaps the most significant factor. The average AT crew or gunner fires comparatively few rounds when compared to the Infantry rifleman. Therefore, training can be expected to have an even greater impact than in small arms evaluation. For example, suppose AT test were being run equating the 106 RR with the ENTAC wire guided missile. Suppose the training literature recommends that 106 crews fire 8 rounds during the basic weapon training cycle and that an ENTAC gunner fires 2 missiles. At the conclusion of the training cycle each of these weapon systems is considered equally combat trained. Suppose now that the hit probabilities are known for groups of trainees and they appear as shown in Figure 1.



HYPOTHETIC COMPARISON OF AT CREW/GUNNER
LEVEL OF PERFORMANCE

Figure 1

The curves show a comparative performance level at the conclusion of basic AT weapon training. However, due to cost and perhaps other practical considerations, the true potential is not known. The plots show a leveling of performance with the 106 RR. The two points on the ENTAC curve show almost nothing concerning what can be expected from the next round. Round 3 may be identical to round 2; may extend outward in a straight line; may improve its performance exponentially; or, more likely, may fall in between.

Perhaps the answer is to use more rounds in training gunners for USAIB tests to insure that performance has peaked. Suppose this were done and the magic number was 10. After ten missiles gunners do not tend to improve performance. Now the question must be answered as to how many rounds does a gunner fire in combat? The average may be three. How can we justify evaluating weapon performance with gunners who have fired 10 rounds in service test training to insure peak performance when the average gunner would rarely fire that many in training and combat combined? This is

a major dilemma in operational testing. When is a gunner trained to the extent he would ordinarily be trained in combat, and how do you get gunners to this level without biasing test results? The discussion under objective 2 attempts to answer the question of how to account for this factor in the operational performance evaluation of AT weapon systems.

(5) Terrain - Analysis of terrain indicates that since terrain affects target acquisition ability, target exposure time and speeds, and the ranges at which acquisition and engagement take place, it does have an impact on weapon evaluation. The manner in which the crew or firer interfaces with the weapon's sighting mechanism or control mechanism, in the case of missile systems, is dependent on the manner in which the firer perceives the target and the area in his field of view. The combat tasks, such as long range aimed fire, are dependent on the accuracy of estimation of the range distance to the target. If the target is moving, lead angle estimation must be made. Target size affects range estimation and target size is equated with surrounding terrain features, such as prominent land marks, buildings or trees, to determine range. All these factors are considered part of the terrain and hence terrain should be an important factor in operational testing.

(6) Vulnerability - Another influencing factor is the vulnerability of competing weapon systems to enemy fire. The amount of the weapon exposed, the weapon signature, and the duration of exposure are critical characteristics in estimating vulnerability. Weapon hardness and whether or not tracking of the target during projectile flight is required are other considerations. The measures necessary to quantify this and other characteristics discussed in the previous paragraphs are discussed under Technical Objective 2, which addresses measures of effectiveness.

b. Technical Objective 2

(1) Introduction - The second objective of the methodology study was to develop techniques and methods for measuring critical factors influencing weapon evaluation. This objective included the development of appropriate statistical sampling methods, experimental design techniques, and analytical techniques. The paragraphs below discuss these efforts in relation to the critical factors associated with the AT weapons system evaluation described in objective 1. The instrumentation systems developed to gather data in real time will be discussed under objective 4.

(2) Weapon Performance Evaluation

The methodology review yielded five combat tasks that are required of AT weapon systems to accomplish the basic combat actions. In addition, the methodology review specified 31 measures of effectiveness that are available to furnish data for the combat tasks. (See Figure 2)

Not all the MOE in the figure are recommended for use. The small arms portion of the methodology study indicated some redundancy in the list of measures. Further, some of the measures are not measures per se but are characteristics of weapon systems, e.g., mount stability. Measures are required to quantify such characteristics. The paragraphs that follow describe each combat task; recommendations as to which MOE are best associated with each task are made.

(a) Long Range Aimed Fire - Several MOE are required to describe this characteristic of AT weapons. The basic MOE used to estimate accuracy is hit probability (P_h). This MOE should be supported as necessary, by several other measures. The rationale for each MOE follows: The basic measure (P_h) reflects the weapon systems ability to achieve hits on targets, given that a tactically realistic target has been acquired and engaged. However, since AT rounds are expensive and generally available in limited numbers for testing, a sufficient number may not be available for reliable P_h estimation. The second measure, miss distance, will provide round to round dispersion data and can be of value in estimating P_h when other constraints prohibit the use of P_h directly. When AT weapons under comparative testing differ widely in characteristics, other hit probability measures must be used. For example, the single shot P_h for the 106 RR may be .5 at a given range while a missile system has a P_h of .8 at the same range. This would indicate that the missile system is superior to the 106 RR. However, during the time it takes to guide the missile to the target the 106 RR crew may be able to fire three rounds each with a P_h of .5 resulting in an engagement hit probability (P_e) of .87, assuming independence between rounds.

$$P_e = 1 - \binom{3}{0} (.5)^0 (.5)^3 = .87$$

Comparison of engagement hit probabilities in this example shows almost no difference in accuracy. This measure accounts for the fact that the effectiveness of long range fire is dependent on the number of rounds a weapon system can dispatch during the period

Number of Hits
Distribution of Near Misses
Engagement Hit Probability
Probability of a First Round Hit
Time to First Round
Time to Reload
Time to First Hit
Time to Prepare to Fire
Time Between Rounds
Time to Shift Fire
Time Between Hits
Sight Manipulation Time
Hits Per Pound
Time to Clear Malfunction
Number of Rounds Between Malfunctions
Ease of Handling
Movement Time
Preparation of Position (Emplacement)
Compatibility with Ancillary Equipment
Maneuverability in Changing Positions or Crossing Obstacles
Time to Dismount/Remount
Crew Training Requirements
Ability to Engage Moving Targets
Sound Level of Muzzle/Back Blast
Obscuration of Target
Visual Light Emission
IR Light Emission
Ability to Operate After Extended Movement
Breakage in Operation Environment
Mount Stability
Stability After Changing Positions

MEASURES OF EFFECTIVENESS

Figure 2

the target is in view. To prevent bias against one of the weapons being evaluated it is extremely important to insure that target in-view time (exposure time) is tactically realistic. This factor is treated further in paragraph (6), Threat.

Since the in-view time selected by the test officer represents only an average in-view time for the terrain and range selected, a fourth MOE is required: time to first hit. This places a premium on the weapon systems responsiveness, placing extra value on the ability to achieve a hit in less time. Regardless of the appropriateness of the target exposure time, the decision maker will have information regarding the weapon's responsiveness, which in turn can be defined as a measure of time required to acquire a sight picture, estimate range, launch and guide, recover and reload.

Since AT weapons systems do differ widely in characteristics, some measure of sustainability should be a part of the decision criteria. The measure of sustainability that should be included is the percent of basic load in terms of number and weight required to achieve a hit. Again, the decision maker should know, for instance, whether a hit probability of .8 for each round of weapon system is represented by a single round in the system's basic load or 3 rounds in the basic load. Finally, an estimate of vulnerability of the candidate weapons is necessary. The MOE suggested is a vulnerability factor which is related to the probability of being detected during the engagement and should be expressed as a function of the physical area of the weapon exposed, duration of exposure, and weapon signature. This measure is discussed in detail in paragraph (7), Vulnerability. Although other MOE may be needed, dependent on the characteristics of the test weapon or ammunition, 7 MOE are required to provide data on the Long Range Aimed Fire task:

First Round Hit Probability

Engagement Hit Probability

Miss Distance

Time to First Hit

Percent of Basic Load per Hit

Vulnerability Factor

Hits Per Pound

(b) Medium Range Aimed Fire - The six MOE mentioned above

will provide the decision base for this combat task.

(c) Short Range Aimed Fire - Again, the six MOE mentioned above will provide the decision base for this combat task, although miss distance will be of less importance at short ranges when P_h and P_e get larger.

(d) Rapid Movement - Rapid Fire - Most of these MOE are from the responsiveness category. Time to first round measures begin when the target comes into view and terminate with the first round fired. The measure should be collected under two conditions for targets of opportunity, while the weapon system is moving and while the weapon system is stationary. If ADP is used for target control, this measure can be collected automatically using the target up/start command and the round count which provides time each round is fired. The firing of subsequent rounds of the same engagement will provide the next responsiveness MOE, time to reload. These data are provided by the round count system. Portability is another category of effectiveness that must be considered. The two MOE are movement speed and time to emplace. These measures provide an estimate of the weapon mobility characteristics, an important factor on the battlefield. In summary, the following MOE are required in addition to the six previously mentioned measures:

Time to First Round

Time to Reload

Movement Time (speed)

Emplacement Time

(e) Rapid Reaction to Suitable Targets - Two measures are required to quantify this task: time to prepare to fire and time to shift fire. Positioning of the missile launch tubes from the carrier to a launching position is an example of the set up activity. Set up time should weigh in the decision process since long preparation time will reduce the ability of the system to engage targets of opportunity. Further, the ability to engage different targets rapidly should be a consideration. Enemy armor can be expected to appear in numbers which places a premium on the ability to shift rapidly as targets move in and out of view. Time to shift fires should be expressed in terms of the angle by which the targets are separated. The two additional measures required are:

Percent of Targets Engaged

Time to shift Fire

(f) Reliability Measures - Other measures that must be considered, although they are independent of a particular combat task, are reliability measures. These measures will permit the calculation of other usable measures such as probability that the weapon will fire properly with each trigger pull. This information should be part of the decision base. Two measures are recommended:

Time to Clear Malfunctions

Number of Rounds between Malfunctions

(g) Other MOE that appear in figure 2 and are not specifically mentioned above must also be considered. These MOE are less suited to objective measurement (e.g. ease of handling) or are redundant with other measures (e.g. number of hits). Most of these MOE are concerned with stability, durability and signature effects. These will be discussed under objective 3.

(3) Human Factors

This section describes the methodology that has been developed in relation to the three critical variables associated with human factors: sampling, motivation, and stress.

(a) Sampling - Statistically sound sampling methods have been used throughout the methodology study to insure adequate, representative samples of test soldiers. These methods are discussed in a technical memorandum which appears in Volume I, Appendix VI. The techniques for estimating sample size and for selecting representative test soldiers generally apply to the AT portion of the methodology study. However, there are some special considerations. These considerations are directly associated with the training of test soldiers for AT weapon evaluation and the transfer effect associated with training on one AT weapon system during advanced Infantry basic training and being selected as a member of a test crew for participation in the service test of other AT weapons. This problem is discussed in paragraph (4), Training.

(b) Motivation - Crew motivation, although critical to operational testing, should not be a difficult factor to include. Because of the expense of AT weapons and munitions, crews during training tend to spend long hours in such activities as dry firing, displacement, road marching, weapon disassembly practice, and cleaning and caring for the weapon. Relatively little live firing is done. Consequently, the problem of motivating a crew under live fire conditions is slight. The opportunity to engage

realistic targets with live rounds or missiles is sufficient motivation providing consideration is given to basic needs. Such MOE as time to prepare to fire or emplace weapon should be used to compare performance of the various test soldiers or crews. Particularly sluggish performance that is consistently observed for one or two soldiers or crews should be investigated by the test officer to determine the cause. The cause may be due to a lack of motivation or some factor such as stability of a particular weapon mount. The specific cause should be determined and noted. This factor may be useful to the statisticians in explaining outliers in the data base which can cause difficulty in the analysis.

(c) Stress - Little is known concerning the quantification of stress caused by being in the combat zone or under fire. It is felt that current stress substitutes, such as sleep deprivation and fatigue, are not adequate. These substitutes tend to impact negatively on motivation, lowering its level somewhat. Combat stress is more likely to increase motivation or to remove the individual from the fire fight entirely, depending on the constitution of the individual involved. The stressed individual who becomes suppressed by incoming fire is likely to be ineffective under any circumstance and hence should not be a consideration in weapon design, employment, or testing. Design parameters and test parameters should be oriented to the highly motivated individual who remains in the battle. Therefore, stress substitutes should not be considered in operational testing, at least until more knowledge concerning stress effect is available. The aim is to keep motivation high and to induce as much realism as possible into the situation. The time pressure of limited target view time is an example of operational realism that should make the test soldier try harder. This is not a stress substitute, but a realistic type of stress.

(4) Training - Closely related to human factors is the training factor, which was found to be an influencing factor in AT weapon evaluation. It is difficult to achieve in a service test the level of training that a combat soldier would have prior to being committed to combat with his weapon system. A test soldier selected to use the weapon to be evaluated may have received training on other AT weapon systems which have a negative transfer value. In other words, previous training will influence the test soldier to perform more poorly than if he had no training at all. If a positive transfer takes place, test results can still be biased since soldiers selected to train on the new weapon system, after it is accepted, may not have had the same prior experience. Over-training can cause problems since the test soldiers may be able to use their skill to overcome weapon deficiencies; this would not occur during wartime when time constraints tend to accelerate training cycles. The recommended means of accounting

for training as an influencing factor is the use of a model. Experience gained during the methodology study indicates that a performance level model could be incorporated into the analysis of comparative performance as new weapons are compared to standard weapons. The model would require the following inputs: number of rounds available for USAIB test, number of rounds that will normally be fired by crew/gunner during normal training, the average estimated number of rounds that would be fired by a single crew/gunner during the combat life of the weapon system. These inputs are summarized below.

(a) Total Rounds Available (T_n)

(b) Number of firings during service training (R_t)

(c) Average number of firings in combat (R_c)

Using these inputs, the model would first produce the following recommendations:

$$R_t + R_c = \text{No of Rounds per Crew/Gunner}$$

This is the number of rounds that is to be fired by each test soldier/crew selected during the service test. The number of crews is also determined by the model

$$\frac{Tn}{R_t + R_c} = \text{No. of Test soldiers/crews}$$

Standard statistical procedures should be applied to determine if the resulting sample size in terms of crews/gunners is deemed sufficient. If the number of crews/gunners is insufficient, more test rounds should be procured. If this is not possible, which will often be the case with new weapon systems, past test experience dictates that evaluation be made using the number of crews/gunners available within the ammunition constraints rather than reducing the number of rounds per crew/gunner. More valid information will be gleaned from testing a few properly trained weapon systems than from testing larger numbers of inadequately trained weapon systems. In one case, the results may suffer from lack of sample size since insufficient sample size will increase the probability of making a statistical error, namely type II error. In the other case, with more but inadequately trained crews, the validity of the test is in doubt. If the validity of the test is in doubt, there is grave, nonquantifiable risk of making an error in judgment concerning the effectiveness of the weapon system on the battlefield. This problem of sample size is discussed

further in Section G, Test Methodology.

It is entirely feasible that the AT weapon system will consist of a single Infantryman who perhaps fires one missile in Advanced Infantry Training and carries one missile into combat. If the test weapon is intended to be used in this manner, the USAIB operational service test should follow the same pattern. If 20 missiles are available for testing, ten soldier/weapon systems should be used, each man firing one training round and each firing one record round.

After the number of potential crews/gunners slots is known, the next step is to select soldiers to fill these slots. Again the significance or prior training as an influencing factor is so strong that the selection of personnel without previous AT weapon experience is dictated. Normal qualifications such as the requirement for special knowledge, aptitutes, qualification test scores should be applied to the man power pool to eliminate those personnel who would not qualify for a normal AT training course. From the population remaining, random selections techniques should be used to fill slots for both the test item and the standard. The training courses should be written and developed uniquely for the weapons being tested to produce the best qualified weapon systems possible regardless of weapon type. The number of rounds normally allotted to training should be used by each weapon system. For instance, if the 106 RR is to be the standard, then the crews should receive all pertinent training prescribed in the appropriate 106 RR training literature (ATC, FM TM, etc.). If one of the weapons is a missile system, appropriate training methods, patterned after other similar AT missile systems, should be used. After training the weapon systems are ready to be used in the operational service test. The number of available weapons systems and the number of rounds available for each system will determine the number of cells in the test design. The development of the test design is discussed in paragraph 5, Test Facility Concepts.

(5) Terrain - Analysis of terrain indicates that since terrain affects target acquisition ability and ranges at which acquisition takes place, it does impact on weapon system evaluation. With conventional weapon systems, performance is extremely dependent on range. Experience with guided missile systems indicates that range dependence exists but with less impact than with conventional weapon systems. The estimation of range is an important factor and hence terrain should be an important consideration in operational testing.

The effects of terrain on the task of engaging an enemy target are intuitively understood although no objective means for quantifying the impact of terrain on weapon system evaluation has been developed. It is suggested that terrain be treated as motivation was treated, that is, incorporate the effects into the test situation as naturally as possible. Testing should not be done in a flat, entirely open terrain in which range estimation becomes difficult. The terrain should have natural features and characteristics common to the environment in which the weapon system is intended for use. In the temperate zone, these characteristics would include trees, ditches, clumps of bushes, fences, and buildings. A battlefield will possibly have shell holes, wrecked or destroyed equipment, smoke plumes, and perhaps prepared positions. Any of these characteristics assist in providing reference points for range estimation. Terrain itself does not appear to be too important providing it is representative and not too sterile.

The recommendation is to insure that the test facility is not an open, flat, known distance type of firing range. Make sure that natural reference points exist in the impact area which can be used either consciously or subconsciously by the crew/gunner of the weapon.

(6) Threat - This influencing factor needs no special attention other than attempting to make target behavior as realistic as possible. Typical in view times and movement speeds should be determined experimentally by using live targets and troops on the test terrain. The test targets should then be programmed as closely as possible to simulate the actions of the attacking force. The measures that should be used in gaging these actions are exposure times, amount of exposed areas, and speeds.

Target size is also important. The effects of scaled-down targets on speed estimation, lead angle, and optical tracking ability are not well understood. Target sizes approximating enemy vehicles eliminates potential problems due to scaling effects. Therefore, full scale targets are recommended. Target instrumentation which will assist in filling this test need is discussed under objective 4.

(7) Vulnerability - Efforts should be made by the test officer to compare the exposed areas, exposed times, and weapon signatures of competing weapon systems in order to express vulnerability in relative terms for weapon evaluation. No special instrumentation is required since the exposed area can be expressed in general terms which are adequate for use in the simple vulnerability model described below. The model will assist in quantitatively

influencing factors that contribute to the detection of weapon systems by the enemy. The model does not yield a probability of detection, per se, but does produce an adequate substitute for decision purposes.

Since the three functions of vulnerability (area exposed, time exposed, signature) represent three measurement scales (meters, time, amount of smoke/flash/sound) they cannot be used directly as interval scales. For example, does one square meter of exposed area equal 3 seconds of exposure time? Since we cannot weight the three scales against each other, a ratio model is recommended of the type:

$$\left(\frac{A_1X}{A_2X}\right)^a \left(\frac{B_1Y}{B_2Y}\right)^b \left(\frac{C_1Z}{C_2Z}\right)^c = \text{Vulnerability}$$

Where A, B, & C are numbers for the area, time and signature (X,Y,Z) and a,b,c are the order of importance as determined by the test officer. If all three are considered equally important, each may be set equal to 1. For the purpose of this analysis, it is assumed that weapon signature is most important and, consequently, c will be assigned a value of 3. Exposure time is considered the second most important factor and is set equal to 2. The least important factor is area exposed (a) which is set equal to 1. To use this model, the test officer estimates the amount of area exposed while performing a combat task, e. g., long range aimed fire. The area my be expressed in any suitable measure, feet. meters, or with such terms as Weapon A has three times more area exposed than weapon B. This technique is permitted since the scales (X,Y,Z) of the model are cancelled out.

$$\left(\frac{A_1X}{A_2X}\right)^a \left(\frac{B_1Y}{B_2Y}\right)^b \left(\frac{C_1Z}{C_2Z}\right)^c$$

Hence the model becomes:

$$\left(\frac{A_1}{A_2}\right)^a \left(\frac{B_1}{B_2}\right)^b \left(\frac{C_1}{C_2}\right)^c$$

The exposed area is substituted for the A values; the exposed time is substituted for the B values; and, signature size for C values. Again, the signature can be expressed in terms of "twice the noise (2:1), or twice the flash (4:1)." The signature can be expressed on a scale from 1 to 5. where 3 represents the standard weapon; any suitable number can be selected for the test

weapon. Using the ratio model, the model is not sensitive to the size of the numbers. Scales will not affect the result. This modeling system was developed by P. A. Bridgeman and appears in his book, Dimensional Analysis, (New Haven, Yale University Press, 1922, P 21-22). If vulnerability varies from combat tasks to combat task, the above procedure can be used to combine tasks. The model is expanded until all tasks are included.

$$\left[\left(\frac{A_1}{A_2}\right)^1 \left(\frac{B_1}{B_2}\right)^2 \left(\frac{C_1}{C_2}\right)^3\right]^a \left[\left(\frac{A_1}{A_2}\right)^1 \left(\frac{B_1}{B_2}\right)^2 \left(\frac{C_1}{C_2}\right)^3\right]^b \cdots \left[\quad\right]^{\text{nth Combat Task}} = \text{Vulnerability}$$

If tasks can be ranked in order of importance in the combat environment, this can be included in the model. The larger numbers represent increasing importance:

$$\left(\begin{matrix}\text{Long range}\\ \text{Armed fire}\end{matrix}\right)^5 \left(\begin{matrix}\text{Medium range}\\ \text{armed fire}\end{matrix}\right)^3 \left(\begin{matrix}\text{Rapid}\\ \text{Movement}\end{matrix}\right)^2 \text{ - - - } (\quad)^{\text{nth Combat Task}} = \text{Vulnerability}$$

This model does not represent the probability of being detected, but since it incorporates the influencing factors in weapon detection, it is directly related. The use of the model will permit inclusion of these factors in the decision process.

c. Technical Objective 3

(1) Introduction - This objective is concerned with influencing factors that are subjective in nature and hence are not easily quantified. The Antitank Project Review isolates 8 categories of measures of effectiveness:

Accuracy

Responsiveness

Sustainability

Reliability

Signature Effects

Portability and Compatibility

Durability

Stability

Of these the first five categories are adequately accounted for objectively by the measures of effectiveness recommended under objective 2. In addition, portability (mobility) is accounted for by MOE reflecting movement speed and dismount and set up times. Compatibility problems are isolated by MOE such as time to reload and time to first rounds, but causes of longer time periods must be identified by observation. These causes can be attributed to man/weapon interface problems, such as smoke or haze from firing, or to difficulty with some aspect of the weapon mount, such as ammunition storage (compatibility), or to one of the other categories of effectiveness: durability or stability. Therefore, although measures exist for isolating problem areas operationally, the cause and effect relationship is largely subjective. Several potential problem areas are discussed below by category.

(2) Compatibility - The subject areas delineated below represent some of the specific, potential problem areas concerning compatibility between the weapon and the crew, the weapon and the mount, and the crew and the mount or platform. The measure time between rounds is an excellent MOE for isolating the existence of a compatibility problem.

Location and use of optical sights

Traversing or tracking mechanism

Vibration from movement or recoil

Backblast

Target obscuration from smoke or haze

Loading

Ammunition storage

Weight of ammunition or components

Interference between crew members

(3) Stability - Stability problems can be isolated with 2 MOE: time to first round and round hit probability. Potential problems with stability include:

Recoil absorption

Ability to relay

Effects of slope

Effects of wet soil

Effects of sandy soil

(4) Durability - Potential problems with durability include:

Weapon support mounts

Weapon recoil mechanism

Firing mechanism

Sighting mechanism

Vehicle carrier/weapon platform

(5) Order of Operational Importance

From an operational standpoint the order of importance of these subjectively evaluated factors can be determined logically. The most severe weapon system problem areas are those which render the weapon ineffective on the battlefield. From an operational standpoint, these problems are as effective as a firepower kill. These failures are by nature associated with the durability of the weapon system. Durability problems can render the weapon completely ineffective and, in fact, can turn the weapon into a liability, a crew that needs protection, a carrier that should be destroyed or evacuated.

The next most important subjective evaluation area is that of stability. An unstable firing platform on which the crew is unable to cope with recoil or rapid displacement will severely reduce the system's combat effectiveness. This contributes directly to a reduction of battlefield effectiveness.

The last category, in terms of relative importance, is compatibility. The effects of shortcomings in design, vibration, etc., can be at least partially overcome by training and desire on the part of the crew. Any shortcomings may contribute to reduced effectiveness but should not, in general, reduce effectiveness as much as stability or durability.

d. Technical Objective 4 -

(1) Introduction - This section summarizes the efforts to develop test facilities and instrumentation that will permit operational field testing of AT weapon systems with a minimum of maintenance and technical support. The development of instrumentation subsystems for use on AT ranges has been oriented in two areas: moving target carriers and automatic scoring techniques. Other subsystems such as miss distance indicators, round count sensors, and radio data links developed

for small arms evaluation also have value in AT weapon evaluation.

(2) Hit Sensing System - The testing of large caliber projectiles or missiles will normally entail the firing of just a few rounds, which can be scored visually. Under these conditions no automatic scoring system is required. Scoring simply consists of keeping track of each round fired by each weapon/crew as a function of time, target velocity, light and wind conditions, range, target size, and whether or not the round hit the target.

For smaller caliber weapons in which the terminal effects of the round are not readily visible, or in which high firing rates are used, an automatic system may be required. Tests with the honeycomb hit skin were successful, indicating that the hit scoring material with appropriate signal conditioning may be used. Stationary targets may use either wire or radio data links; moving targets will require radio data link. A complete description of the honeycomb hit scoring material appears in Appendix IV. Basically, the material has many advantages including low cost and its firm yet brittle structure. This last characteristic permits the AT round to punch out very clean holes as it passes through causing relatively little damage. Scoring is accomplished by placing aluminum foil or screen over the exterior surfaces in such a manner that the front and rear surfaces do not contact each other. A potential is placed across the two foils. The projectile passing through creates a temporary short causing the potential to drop. The drop in potential is sensed and a hit pulse is produced and sent to the recorder or ADP. The Joanell signal conditioner currently on hand is adequate for the scoring system. The oscillograph or ADPS can be used as a recorder.

In addition, a vibration sensitive crystal accelerameter has been tested with the honeycomb foil as a hit scorer. Initial tests indicated that the accelerameter scorer is feasible. Some difficulty was experienced due to target motion which caused the accelerameter to trigger intermittently. It was felt that this problem could be eliminated with noise suppressing circuitry. No signal conditioning is currently available.

Finally, a strain gage sensing system was studied but not field tested. The results of the evaluation of this concept were positive, indicating some potential as a scoring system.

Both the accelerameter and strain gage will be sensitive to the amount of impact, hence the size of the projectile. As the round gets smaller, sensing becomes increasingly difficult. The electrical system appears to be less dependent on projectile size.

The projectile, however, must be long enough to span the distance between the electrically charged layers. The minimum size with the present system is the .50-caliber projectile.

All of the hit sensing systems mentioned above should include the capability of igniting a pyrotechnique device to insure that the gunner is aware that a hit has occurred. Such a capability will not be necessary except for small caliber or low signature rounds in which the occurrence of a hit may not be visible to the gunner/crew.

(3) Target Carriers - Three target carriers have been developed at the USAIB for tank type targets: a stationary pop-up, and intermediate speed (10-25 mph), and a high speed (35 mph).

The pop-up unit is of a simple, reliable design that uses a released counter weight as an activating mechanism. It is reset manually. Modifications are underway to design an automatic reset capability.

The intermediate speed (MTV-300) tank type target is capable of carrying a $7\frac{1}{2}$' x 15' panel at speeds uo to 25 mph. The unit is based on the design of the personnel target used on the small arms facility. The unit consists of a set of tracks in a straight line up to 2,000 feet long. Power is provided via a continuous cable from the drive unit to the carrying vehicle. The system has a full cycle capability; that is, once started, the carrier will travel the length of the track, stop, and return to the starting position automatically. The main drive unit is powered by a 220-volt, 5-HP electric motor.

The high speed target unit (MTV-400) uses the same track as the MTV-300, but employs a self-propelled carrier vehicle to achieve the desired speeds. The length of track is basically unlimited and controlled speeds to 35 mph are possible according to design specifications. The unit has been tested and found operable at speeds to 50 mph. It is powered by a 25-HP industrial gasoline engine and has full cycle automatic control.

(4) Data Link - The basic data link is identical to the moving man target data link with approximately 2-watt output at a frequency of 86 megacycles. The transmitter is crystal controlled, using a modulated tone. It is capable of transmitting a single channel of information and is normally used to carry hit data. The receiver is a Nehmes-Clark FM unit and is connected to signal conditioning which in turn can be used with ADP or other recording media.

The data link is equipped with a pulse coded system which severely reduces the probability of recording noise signals as data. A hit is preconditioned into a short series of precisely spaced pulses of specified width and amplitude. This series must appear at the decoder unit before the appropriate hit pulse is sent to the recorder. This prevents extraneous pulses from

such sources as antenna noise and electrostatic interference from being interpreted as a hit.

USAIB also has on hand two 5-channel IRIG telemetry transmitters. These were designed to carry one channel of hit information and four channels of miss distance information. The receiver mentioned above is used with a set of discriminators to reduce the composite signal into its five component channels. The system has not been tested on the new target systems.

(5) Round Count - The round count system normally used for small arms is available for use with AT Weapons. Transducer signal conditioning may have to be developed to insure compatibility with the various types of AT weapons if the audio signature is of low amplitude. Virtually all AT weapons have some audio signature upon trigger pull that can be used by the system. The transducer can feed the ADP or a recorder with appropriate signal conditioning as necessary.

(6) Miss Distance - If miss distance is required, the standard time difference system (TDMDI) will suffice for supersonic rounds against stationary targets. Experience with large caliber rounds indicates that extreme scoring accuracy can be achieved with the TDMDI. The large caliber rounds are precisely machined and are extremely stable in flight and, consequently, produce an excellent, high amplitude shock wave. Subsonic near miss scoring causes a much greater problem. The large cross section of the round will produce a good radar scoring signature, but available radar systems do not yield X, Y coordinate information. The most commonly employed system is a two-camera system in which a camera behind the projectile is used to produce film from which miss distance is measured. A second camera running synchronously and placed in the target plane determines which frame is used for the miss distance measurement. Optical tracking systems using cinephototheodolites will produce reliable data but require expensive installations. Both photographic systems are cumbersome in terms of data reduction and are unsuitable if large numbers of rounds are to be fired. Normally, however, large numbers of rounds will produce reliable hit probability thereby reducing the need for miss distance information.

The large caliber projectile lends itself to still another type of miss distance indicator that was proposed by Westinghouse. This system consists of a mercury lamp shining directly upwards creating a light screen not visible during daylight from the weapon position. Projectiles passing through the screen reflect light downward to two sensors composed of fiber optics. The angle of reflection is used to determine the point of penetration.

The moving target is a complicating factor. Two methods are available for scoring hypersonic rounds: a ground-mounted TDMDI system in which the location of the target is known or a vehicle-mounted TDMDI system. Both systems have advantages and disadvantages. The ground-mounted system is conceptually simple. A row of sensors, spaced approximately 60 feet apart, is placed along the path of the target. Switches along the track feed the ADP system with pulses as the target moves along. Speed is measured constantly and target position can be computed at any moment. As rounds pass over the track, the sensors receive the shock wave and time of arrival can be used to determine X, Y coordinate of the passing round. By determining the position of the target from the track switch information, miss distance can be computed. The advantage of this system is that the state of the art in terms of data transmission (wire) and signal conditioning is well within USAIB capability. The disadvantage is the use of large numbers of sensors, hence large amounts of wire.

An alternate system is to carry the sensors on the vehicle and radio the data to the ADP. The advantage is that the MDI is always referenced to the target. The disadvantage is that the telemetry data link is extremely sophisticated and will be difficult to maintain and repair without improved test equipment.

The moving target system presents no particular problem to scoring subsonic rounds using optical scoring methods.

(7) Conclusion - Although much work has been accomplished in the development of AT instrumentation systems and the components necessary for AT weapon performance evaluation are available, no antitank experiment has been conducted. At the present time, the systems described here are planned for use, as necessary, in support of the forthcoming DRAGON test. This test will replace the test vehicle originally planned for use during the methodology study, Antitank Experiment 1. Instrumentation systems that prove valuable during the DRAGON test will become an integral part of the antitank test facility.

5. TEST FACILITY CONCEPT

a. Introduction - The development of test facilities which will permit operational testing of candidate weapon systems draws heavily on objective 1, Critical Factors Influencing Weapon Effectiveness, and the small arms portion of the methodology study for instrumentation development.

Annex H of the Antitank Methodology Review (Appendix II) describes an adequate physical test facility. The facility described provides the following necessary characteristics:

(1) Sufficient terrain for fire movement

(2) Range safety fans to test the weapon system in a shift fire mode and at maximum effective range

(3) Realistic stationary and moving targets at representative range distances

(4) Prepared defensive and assault firing positions

(5) Point fire, rapid reaction targets

b. Sufficient Terrain for Fire and Movement - An operational test environment must provide the type of test environment that the weapon can be expected to encounter in combat. Ideally, the weapon should engage, displace to alternate positions and reengage; it should be tested on how well the combat tasks are accomplished.

The five combat tasks which are required to complete the 25 combat actions outlined in the review must be an integral part of the range. Again, these tasks are:

Long range aimed fire

Medium range aimed fire

Short range aimed fire

Rapids movement - rapid fire

Rapid reaction to suitable targets

Movement times, firing times and accuracy are all viable measures. The movement times and set up times can be measured with stop watch or event switches connected directly with the ADP. The magnitude of the test should be the major consideration; hits can be scored visually or by instrumentation depending primarily on the number of rounds to be fired and the size of the impact signature.

c. Range Safety Fan for Shifting Fire - To measure time to shift fire adequately, the gunner must be made to go through the entire sequence of acquisition, aiming and firing two times at two different targets. To test the weapon's capability, the new target must lie outside of the field of view of the aiming optics so that the firer is forced to reacquire and engage after defeating the first target. Normally, the field of view for AT aiming optics is approximately 8 degrees. Since the target is normally placed in the center of the field of view, a second target will have to be separated by at least 4 degrees to be outside of the field of view. At a range of 1,000 meters, target separation will have to be greater than 70 meters. At 2,000 meters, separation will have to exceed 140 meters to provide time to shift fire data. The range safety fan must permit engagements of targets at the weapon's maximum effective range, although sufficient width to shift fire at that range is not necessary.

d. Realistic Stationary and Moving Targets - To duplicate plausibly an enemy threat, targets must be used in a realistic manner. Speeds approximating wheeled and track laying enemy vehicles must be reproduced by the moving targets. Realistic exposure times and exposed areas must be reproduced by the stationary targets. The stationary targets may be able to simulate adequately incoming moving targets by very slowly coming up and going down, giving the appearance of moving armor approaching on undulating terrain. These speeds and approach times should be determined by the actual use of an attacking force on the test terrain. Target parameters can be determined from these data.

e. Prepared Defensive and Assault Positions - To insure identical replications, weapons should fire from prepared firing positions in both the defensive and assault roles. This also permits the placement of round count microphones and cameras for data collection without interferring with the tactical operation of the weapon system. Triggering devices or manual triggering can be used to sense the arrival of the weapon at these positions, insuring identical target presentations from trial to trial.

f. Point Fire - Rapid Reaction Targets - For candidate weapons with a rapid reaction capability, targets of opportunity should be presented at inopportune times to assess the weapon's capability to react quickly. The need for quick reaction is enhanced by close range conflict normally represented by a point

fire situation where no time is available for laying the weapon accurately. This situation is related to the small arms quickfire capability which proved very sensitive to small differences between weapons.

g. Recommendations - All of the above considerations should be included in the setting up of a test facility to evaluate the performance of a particular weapon system. Reference should be made to the Appendices I and II which present detailed descriptions of an AT test facility and test facility instrumentation. The limiting factor in determining the number and types of targets, engagement ranges and engagement lengths will be the number of test rounds and crews available. These factors are discussed in the next section. Instrumentation should be adapted to the characteristics of the test and standard weapon. During the DRAGON testing, for instance, visual scoring with photographic miss distance and manual timing of events will suffice because of the relatively large projectile and slow firing rate. The critical factors mentioned under Objectives 1 and 2 should be reviewed and incorporated as described in those sections.

6. TEST METHODOLOGY

a. Introduction - In the operational service test the first considerations are the objectives of the test. Once these are defined and understood a test design should be prepared which will provide the maximum information concerning performance that can be acquired within the constraints of the test. In most cases the major constraint will be time and ammunition. After the test design is completed, instrumentation systems must be implaced to provide the basic data for each cell in the test design. Physical conditions, which insure the inclusion of critical factors and which are required for an operational test, must be set up and a schedule of events must be programmed. The next effort is the careful implementation of the test plan and the collection of the data. Finally, the analysis based on the test design is completed. The basic steps are summarized below:

Objectives

Test Design

Range Design

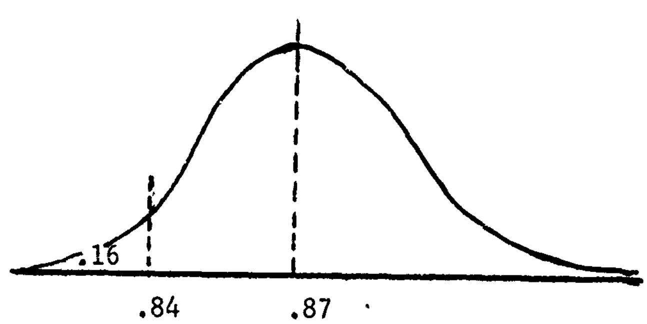
Instrumentation Selection

Instrumentation

Analysis

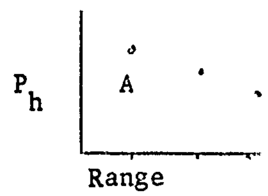
b. Objectives - Although the responsibility for test objectives does not normally belong to USAIB since objectives are usually provided with the test item, it is the Board's responsibility to determine if the objectives provided are consistent with good field test procedures.

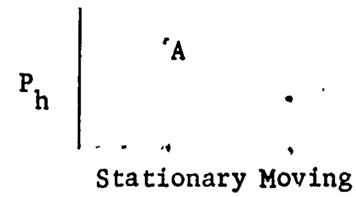
Suppose, for instance, that a test directive were received to test a new AT weapon system. The test was to be run against a standard AT weapon system. The objective was to determine if the new system represented at least 20-percent improvement in hit probability (P_h) over the standard weapon. Assume that the P_h for the standard was equal to .7 at 1400 meters. A 20-percent improvement would mean that the P_h for the new system would have to be equal to or greater than .84 (20% of .7 = .14) at the same range. Assume the directive sets the confidence level at 90 percent. We must be 90-percent confident that the new system is at least 20 percent better in P_h than the standard. USAIB would receive 100 weapon systems (missiles) for the test. To fulfill the objective all 100 missiles would have to be fired at under precisely controlled conditions (similar target, similar firing position, same range, etc.). If indeed the P_h were truly .87, it can be shown that the probability of rejecting the test item is as high as 16 percent. Consequently, we will have expended all the test items having gained very little knowledge concerning operational effectiveness, and we will still have a high probability of making a wrong decision based on the outcome of the test. We will know nothing concerning the effects of target speed, exposure time, approach angle, image size, or range on the weapon system. A sample size of 100 rounds is sufficient to provide much information concerning the capabilities of a new system with appropriate objective and test design. If it is desired to be 90-percent confident that the new system is a 20-percent improvement, the system has to have an inherent capability much greater than .84 (for the example above). If the system had true P_h of .87 there exist a probability of about .16 that the new system would be considered unacceptable based on the data from 100 missiles. The graph below uses the normal approximation to the binominal and shows the distribution of probability estimates based on missiles coming from a population that has a true P_h of .87. It shows that a 16-percent chance exists



of pulling a sample of 100 missiles that have an estimate P_h less than .84.

c. Test Design - In designing the operational service test every effort should be made to permit data to be used under as many cell conditions as possible. Suppose we wish to determine P_h as a function of range and we are also required to determine the degradation factor due to a target speed of 10 mph. Two curves would be required:





In each case the same sample could be used for the point marked A. Rounds fired at a stationary target in the speed degradation test could also be used to fill one of the cells required to determine the effects of range; much overlap can be designed into the test reducing the number of rounds required or, conversely, increasing the amount of information from the number of rounds available.

The number of cells in the design that must be filled must be tempered with the number of weapon systems available. The training model will dictate the number of weapons systems available and the number of rounds each will be able to contribute to the design. The number of weapon system times the number of rounds after training allotted to each system will equal the total sample available which must be divided into the test design cells according to the sample size required by each cell. If the cells are too numerous to be adequately supplied, some design trade offs will be required.

For instance, if a 106 RR team normally fires 24 rounds on the average during its life cycle, 10 of which are training rounds, then each team can contribute 14 rounds to the test design; that is, the 10th through the 24th round of its life cycle. If the weapon system is a missile system with a total life of five rounds, two of which are fired on training, the system can contribute three more firings, its third, fourth, and fifth, to the test design.

From a statistical standpoint it is better to reduce the cells than to dilute the sample. However, statistical considerations are rarely the only considerations. It may be more important, for instance, to achieve a rough estimate for a cell mean than to achieve statistical reliability. These decisions must be made after the constraints are known.

d. Range Design - The test facility should be configured as required in the test design. Some considerations are the number and types of firing positions, the location of targets, and the placing of reference points for such tasks as estimation of range. The range design will insure that weapon crews perform the critical combat tasks and actions. The ability to generalize the test results from the test environment to the combat environment is dependent on how well the influencing factors of combat are represented on the test facility.

e. Instrumentation Selection - Appropriate instrumentation, including sensors, data link, recording media, must be selected to provide the basic data required by the test design. The final conclusions are dependent on the accuracy and reliability of the data provided by instrumented and manual data collection systems. Where possible redundancy should be built into the data collection system because of the importance of individual rounds. When compared to small arms, an AT round or missile represents a sizeable investment, and large numbers of test items are not normally available. Poor test designs can be reviewed and rewritten prior to a field test. Analysis can be redone as long as the basic data exist. But, test rounds cannot be refired nor can data be recollected if missed. In the operational test each round is valuable and the conditions under which it is expended should be precisely governed in order that its contribution to the data base be substantive.

f. Implementation - The implementation of an operational field is fraught with problems causing the test officer to make an almost continuous stream of decisions. The problems include such things as crew members becoming ill and a decision must be made either to substitute a man from another crew, substitute the entire crew, substitute the crew and the weapon, delete or postpone the engagement. If a target fails to function, another myriad of problems surface. The misfiring of a round, the breakdown of a recorder, the occurrence of inclement weather each require decisions which can have a degrading influence on the data base, time schedule, and the test design. The statistician, the test engineer or technician, and computer specialist should be on hand to provide guidance concerning the potential impact of the problem in those special areas.

The complex nature of this type of testing requires that wisdom and insight be used in solving test problems. A record of each problem and the resulting decision should be made for the person responsible for data analysis. When deviations from the test schedule occur, data intended for one cell can become data for another cell. If the analyst is unaware of such changes, these data become outliers in the data base which he cannot explain and which reduce data reliability.

g. Analysis - The data analysis should be geared directly to answering the test objectives. Statistical test computer routines are available for use. After the objectives have been addressed, the data base should be sifted again to glean information that may be of value above that required for the objectives. The data base may be useful for weighting MOE or resolving other methodological problems. A recommended analytical procedure appears in Appendix V.

APPENDIX I

PROJECT ANALYSIS
ANTITANK WEAPONS TEST RANGE

(DRAFT)

DRAFT

PROJECT ANALYSIS

ANTI-TANK WEAPONS TEST RANGE

Contract DA EA 18-68-C-0004

9 January 1970

Mellonics Systems Development

Division, Litton Systems, Inc.

1340 Munras Avenue

Monterey, California 93940

DRAFT

TABLE OF CONTENTS

Section 1

INTRODUCTION AND SUMMARY

This project analysis has been performed under contract DA EA-18-68-C-0004 in connection with the Infantry Weapons Test Methodology Study conducted under U.S. Army Infantry Board (USAIB) auspices at Fort Benning, Georgia. The scope of the analysis includes the design, development, and use of an instrumented range for test and evaluation of anti-tank weapons systems in a quasi-combat environment.

The test range will yield quantitative data for evaluating anti-tank weapons systems under operational conditions. Combat realism will be enhanced by a limited capability for simulating two-sided engagements (return fire). Thus, the range will not only permit controlled observation of testing and variation of test conditions to obtain quantitative measures, but will produce data related to the subjective aspects of weapon system evaluation with special emphasis on human factors. These features will prove invaluable in comparative testing of two or more candidate weapon systems.

The purpose of this analysis is to furnish guidelines in the development of an anti-tank weapons systems test range, to establish basic test concepts, to make a preliminary determination of terrain and instrumentation requirements, and to obtain an estimate of data collection and processing requirements.

Section 2

STATEMENT OF OBJECTIVES

OBJECTIVES

The objectives in establishing an anti-tank weapons system test and evaluation range will be:

1. To develop and evaluate methodologies for testing infantry associated anti-tank weapons systems under quasi-combat conditions.

2. To identify those factors which are critical in testing and comparative evaluation in such an environment.

3. To obtain field test data as a basis for establishing measures of system effectiveness.

4. To develop objective standards for comparing system effectiveness.

Section 3

ANALYSIS OF CRITICAL FACTORS

1. TERRAIN

Terrain may prove to be a critical factor in conducting anti-tank weapons tests at Fort Benning. If the tests are to accomodate the full spectrum of anti-tank weaponry in current use and under development for the 1970-75 time frame, the following minimum requirements should be met:

a. Provision for engagement ranges from 100 to 3000 meters.

b. A range safety fan extending to 5000 meters and allowing for maximum expected angular dispersion of fire.

c. Reasonably flat terrain to eliminate line-of-signt problems, except where called for in test scenarios.

d. Provision for removing the target(s) from the range fan for maintenance and adjustment (to eliminate the necessity for clearing "duds").

A schematic diagram of a range satisfying these constraints is presented in Figure 1 . The diagram shows three firing positions, (1) for long engagement ranges (1500-3000 meters), (2) for medium ranges (1200-2000 meters), and (3) for short ranges (100-1200 meters). Alternate positions could also be specified. The actual dimensions and angular widths of the

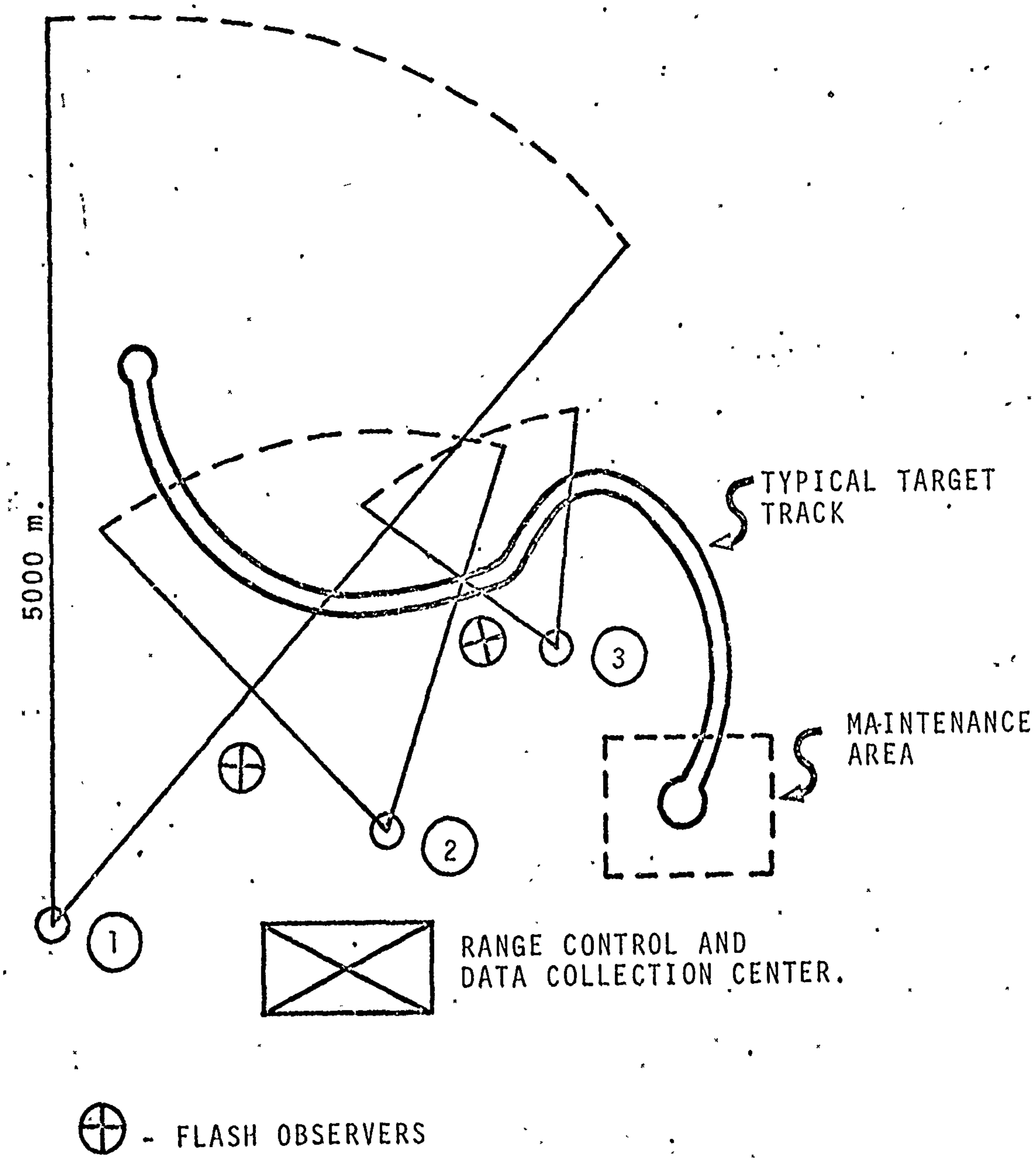


Figure 1. Anti-Tank Test Range Schematic.

range fans should be established on the basis of expected weapon/crew performance, and are shown here for illustrative purposes only.

The target track shown has been selected to present a variety of presentation angles and angular motion rates to the weapon crew. This, also, would be subject to change for a given scenario.

Intervisibility constraints could be introduced by using brush screens, earth mounds, or natural obscurae such as trees or hills.

2. <u>WEAPON AND CREW VULNERABILITY</u>

The degree to which the weapon and crew are vulnerable to return fire in an anti-tank operation in an important factor in assessing the value of an anti-tank weapons system.

The basic measure of vulnerability is exposure time, which is the total length of time during which the weapon and/or crew could be seen from the target as it proceeds along its course. Use of this measure alone would result in a pessimistic estimate of crew vulnerability, as it assumes a 360° field of view for the tank as well as instant acquisition of the anti-tank weapon by the tank crew.

A more realistic assessment would take into account the fact that the attention of the tank crew is generally directed forward, and that often acquisition does not occur until the anti-tank crew reveals its presence by firing a round. Further, the weapon-target range is an important consideration in determining whether or not the weapon would have been detected.

Weapon/crew exposure can be measured in a test situation by stationing an observer in a forward position (outside of the range safety fan) equipped with binoculars and watch synchronized with the range master clock. The observer maintains a log of crew activity, noting times when the crew or weapon, in his opinion, would have been apparent to a tank at an appropriate range. To reduce bias introduced by judgment, observers will have special training and will be given objective criteria as to the degree of exposure required.

Observer data can be correlated with target location and bearing data after the test to derive a more realistic value for exposure time, correcting for actual orientation of the tank when exposure occurred.

Further evaluation of crew/weapon vulnerability would consider return fire from the tank. In this situation, time to acquire to train turrets (as a function of rotation angle) and to aim guns must be established and correlated with the actual exposure profile. Normally, these times would be determined in advance.

3. NIGHT OPERATIONS

Anti-tank weapons systems equiped with or operated in conjunction with low-light vision aids such as passive night vision devices (PNVD) or infrared detectors should be tested in night operations. Such tests are critical in evaluating systems which use image intensifiers, because such equipment is subject to "blinding" by muzzle flash, shell detonations, artificial light sources such as vehicle headlights, and other phenomena resulting in transient increases in local or ambient level of illumination.

If infrared detectors are to be tested, a means of simulating the infrared signature of the target should be devised. A simple and cost-effective technique would be to install a wire mesh on the outside surface which could be maintained at a desired temperature electrically.

4. COST EFFECTIVENESS

Anti-tank weapons tests are characterized by relatively low rates of fire using relatively expensive rounds, particularly when dealing with ATGM systems. Both of these factors will limit the use of test replication as a means of achieving statistical significance, and place a premium on thorough test design. In particular, variables not subject to evaluation must be rigidly controlled or established prior to testing by special crew training, weapon boresighting, and other precautionary measures.

if a digital computer is available, the use of simulation and war gaming would be a valuable aid in designing test scenarios. Benefits to be expected from this approach include the identification of critical event sequences and elimination of redundant or unnecessary features in proposed test procedures.

The computer could also be used to derive additional information from test results, using actual test data as input to a generalized tank-infantry engagement model, of which several are in present use.

Section 4

TEST VARIABLES

Three categories of variables will be considered in conducting anti-tank weapons systems testing: independent, dependent, and random. Variables within these categories are listed below:

1. Independent Variables

These are subject to control, and will be established prior to testing:

a. Engagement range
b. Target characteristics
c. Target course and maneuvers
d. Weapon location
e. Target exposure times
f. Weapon type
g. Round type
h. Crew proficiency
i. Target illumination

2. Dependent Variables

a. Time to acquire target
b. Load and reload times (recoilless rifles)
c. Pickup and tracking times (missiles)
d. Time to land a spotting round
e. Range estimation by crew
f. Rounds expended to kill
g. Aiming errors

3. Random Variables

a. Natural light
b. Weather
c. System malfunction
d. Ballistics
e. Crew error

Variables to be measured in conducting anti-tank weapons tests will include the following:

1. Point of Impact

The point of impact for each round on target will be determined by reducing data generated by sensors associated with the target. Candidate sensor systems include pressure or acceleration transducers and a variety of imbedded electrical grid configurations connected via radio link or land line to a data collection center.

2. Miss Distance

Near-miss data, if required, can be obtained by acoustic instrumentation mounted on the target. An alternate scheme, which may prove feasible in testing missile systems, would employ an RF beacon mounted on the projectile and tracked by antennas suitably deployed on the test range.

3. Response Times

These are measures of time required by the anti-tank weapon to accomplish required tasks, including but not necessarily limited to target identification and acquisition, range estimation, weapon loading, emplacement of spotting rounds, target tracking, weapon reload, and target shifting. The simplest method of measuring response time is to employ an

observer equipped with checklist and stopwatch. Correlation of data would be facilitated if the observer were further equipped with a device to transmit event data to the data collection center in real time.

4. Round Count

5. Target Location Errors

Correlation of estimated target locations and actual target locations derived from the scenario or by range tracking equipment will provide an objective measurement of observer performance.

6. Environmental Factors

Wind velocity and direction, ambient light, visibility and other factors affecting mission performance will be measured objectively or will be categorized (e.g., good, fair, poor).

Section 5

TEST CONCEPTS

Test concepts to be employed on the anti-tank test range will be predicated upon anticipated weapons systems requirements in the 1970-1975 time period, with frequent review and update as new requirements become known.

Test concepts will be based upon three classes of weapons currently in use or in an advanced state of development:

a. 106MM Recoilless Rifle, M40
b. Light Assault Weapon (LAW), M72
c. Heavy Assault Weapon (HAW), TOW ATGM

Other weapons (e.g., 90MM recoilless rifle, 120MM recoilless rifle, Dragon, ENTAC) which are similar in basic concept to those enumerated above should be adaptable to the test range without significant alterations in test procedures or range instrumentation. A brief description of a test procedure will be presented for illustrative purposes.

TEST PROCEDURES

As indicated above, the 106MM recoilless rifle, M40, will be the baseline weapon system for this class of anti-tank weapon. Tests will be conducted using a .50 caliber spotting rifle (M8C) to estimate target range and bearing. A typical test might proceed thus:

1. The weapon crew emplaces and loads the weapon and any visual aid devices appropriate to the scenario. Upon completion of this task, test

observers (as required) assume their stations and a ready signal is issued to Range Control.

2. Target motion is initiated by Range Control out of view of the weapon crew after a delay, the duration of which is not known to the crew.

3. The following sequence of events occurs, and the corresponding times are logged by a test observer:

   a. Target appearance
   b. Target identification
   c. Fire spotting round
   d. Repeat (c), if a miss results
   e. Hit on target by spotting round
   f. Fire anti-tank round (inert).
   g. Reload and repeat (f), if miss
   h. Hit on target
   i. Repeat (f), if not a kill (M or F)
   j. Target disappearance of halt (M-Kill)

Engagement ranges will be varied, from 300 to 1500 meters, to provide a realistic evaluation of P_k as a function of range. A suitable choice of target course will provide a capability for evaluating aiming performance for a variety of viewing angles and angular rates within the weapon field of view.

A further refinement could be introduced to evaluate crew reaction: The target would be programmed to proceed until the weapon crew has revealed its presence*, at which time it

* Either by firing a round or by exposure within the tank's field of view, as determined by a test observer.

would commence return fire. Assuming that P_k is inversely proportional to range for both weapons, an interesting gaming aspect could be introduced, as described in the following paragraph.

If the commencement of anti-tank firing is at the discretion of the weapon crew, it may elect not to fire until the target range has been reduced to provide an acceptably high P_k. However, a delay permitting closer approach may result in excessive exposure to return fire. At this point, load and reload times and gunner accuracy become critically important.

Tests of ATGM systems would proceed along similar lines, except that longer engagement ranges could be used. Test scenarios would be developed to evaluate system capabilities such as the following:

a. Ability of the weapon crew to maintain track in the presence of temporary obscuration, changes in target aspect, and changes in target course.

b. Ability of the system to respond to high angular rates such as might be encountered in shifting targets subsequent to launch.

c. Ability of the automatic tracking equipment to maintain lock in the presence of other visual/infrared sources and signal attenuation due to dust or smoke.

INSTRUMENTATION

TARGET CHARACTERISTICS

To obtain meaningful measures of anti-tank weapons system effectiveness under quasi-combat conditions, the target/hit sensing subsystem should possess the following attributes:

a. Immediate and recognizable results of anti-tank gunnery should be provided to the crew.

b. The target should resemble a typical tank from all viewing angles (front, rear, side, quarter).

c. The target should be capable of simulating tank motion and maneuver capability.

d. The target should be instrumented to provide automatic hit and near miss scoring.

e. The target should be capable of surviving multiple hits by inert rounds.

Each of the above will be discussed in further detail in the following paragraphs.

1. Visual Cues

To provide the gunner crew with realistic conditions, the visual cues associated with a hit on target should be present. Assuming that inert rounds are used to reduce target attrition, it will be necessary for the target itself to provide cues in the form of light flashes and/or smoke puffs, preferably triggered at a point near the actual impact. Further realism could be introduced by programming the target to stop in the event of a hit so located (e.g., on the treads) as to disable a tank.

2. Three-Dimensional Target

The visual cross section of a tank varies markedly with viewing angle, and this in turn affects detection and aiming accuracy. A three-dimensional replaceable shell equiped with hit sensors and mounted on a heavily armored mobile carriage is a feasible and cost-effective method for providing a realistic simulation of a tank.

It may be desirable to introduce a certain degree of two sided combat into the anti-tank weapons test program. This may be readily accomplished by equipping the tank with a trainable turret and gunfire simulators.

3. Target Motion

To enhance the realism of the engagement, the target should be capable of moving along a pre-programmed path. This path should include turns to alter the viewing angle with respect to the anti-tank gun crew, and should take advantage of various types of obscurae (terrain, vegetation, smoke and dust generated by preset charges, etc.) to provide elements of surprise and reaction time.

Several methods of providing controlled target motion are suggested. The first uses a self-propelled (electric or internal combustion) engine controlled via radio link by an operator or by commands generated by a preprogrammed scenario. The radio link could be replaced by land line, if desired.

A second method employs a buried wire which is laid along the desired course. Electromagnetic sensors in the target vehicle detect variations in distance from the wire, and generate directional corrections to the target control

system. The wire, in addition to providing motion control, may be used to transmit commands to the target vehicle (start, stop, train guns, commence firing, change speed, etc.).

4. Automatic Scoring

Automatic scoring of hits and near misses can be accomplished by transmitting target sensor data to the range data collection center via radio link, land line, or via the above mentioned buried wire, if this is the target control method used. To enhance the validity of test results, it would be desirable to record the actual point of impact on the target or at least to determine the general impact area. This will permit more precise measurement of kill probability in that variations in vulnerability over the target surface to a given anti-tank weapon system can be taken into account. In particular, it may be desirable to differentiate between mobility (M) kills and firepower (F) kills.

5. Target Survivability

Cost-effectiveness considerations dictate that the target/sensor subsystem be capable of surviving multiple hits without significant degradation in performance over a reasonable life cycle.

Consideration of candidate hit-sensing systems indicates that electromechanical impact sensors (accelerometers, piezoelectric devices, etc.) may not perform adequately in the presence of non-projectile induced accelerations due to target motion and are liable to record false hits resulting from flying debris.

Significantly better performance can be expected from sensing systems activated by a change in electrical

properties resulting from rupture or deformation of the target material by a metallic projectile. Several systems have been tested of which Hitskin, manufactured by Joanell Laboratories, appears to be highly suitable for this application.

Hitskin employs two parallel grids imbedded in a plastic sheet ("skin"). A dc voltage is maintained between the grids and is monitored by the hit scoring subsystem. A projectile passing through the target contacts both grids simultaneously, generating an electric pulse for the duration of its passage.

Short circuits formed by deformation of the target surface can be readily removed by impressing a high voltage on the target to burn away the contacting grids and restore the sensor system to full efficiency. It is expected that, considering the relatively low rates of fire employed in anti-tank operations, a single target will be reusable for many test cycles. The Hitskin system has the further advantages of being insensitive to vibration or minor structural deformation and of permitting separate instrumentation of selected areas on the target surface to allow the vulnerability analyses referred to above.

DATA TRANSMISSION

The anti-tank range data transmission system will perform two basic functions: the data link subsystem will relay target sensor data to the collection center, and the command link subsystem will relay target commands from the control center to the target/sensor subsystem. A block diagram of the data transmission system is given in Figure 2 to illustrat_ the interrelationship of the data and command link subsystems.

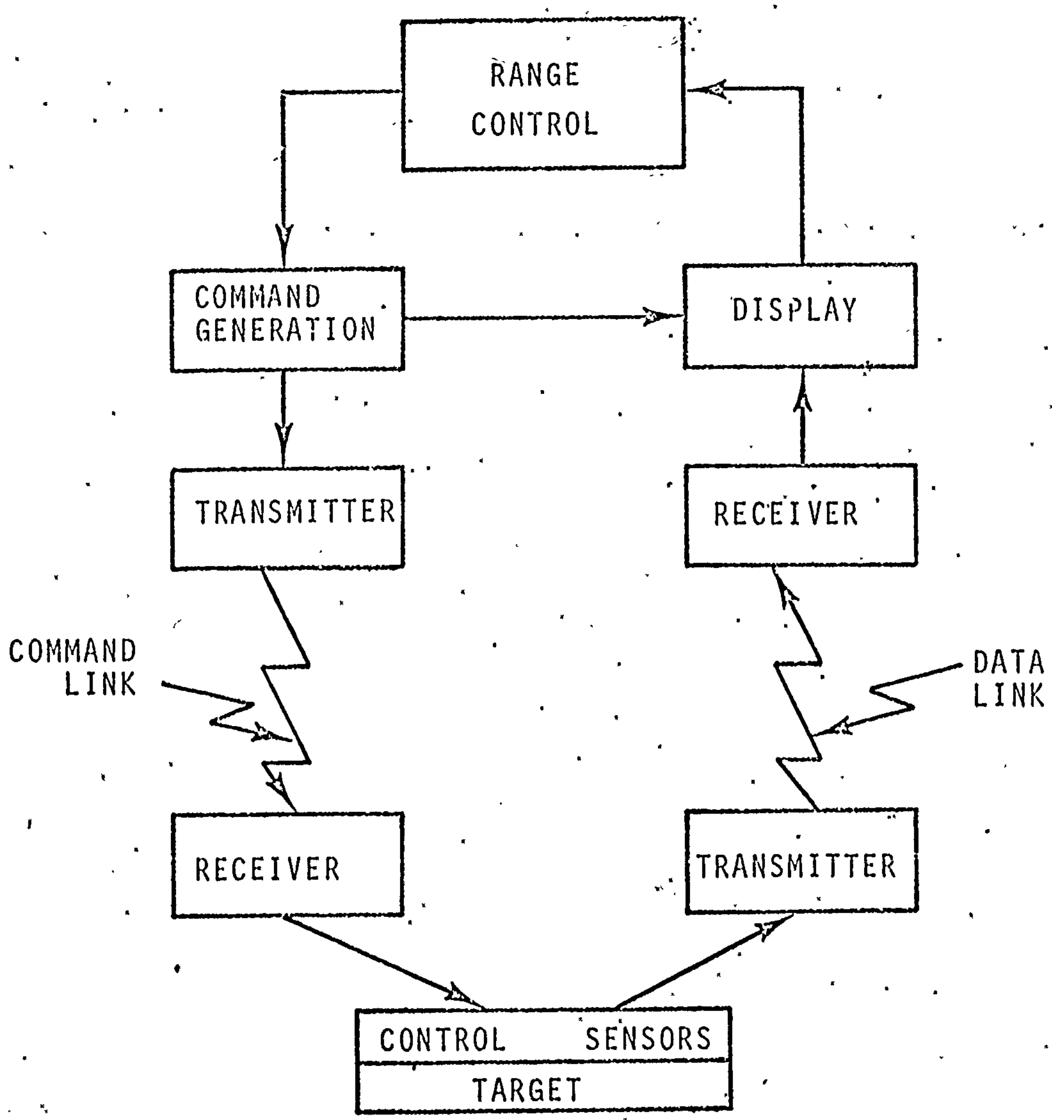


Figure 2. Data Transmission System.

Two basic methods for implementing the link subsystem should be considered: direct or "hard" wiring via land line and radio frequency (RF) or telemetry. The advantages of land lines are low cost, reliability, design simplicity and ready availability of off-the-shelf components. Where the target complex must be mobile or is located at a considerable distance from the control center, RF or telemetry link is an attractive alternative. The anti-tank range will impose such requirements; hence, the analysis will be directed toward the use of RF links for both data and command transmission.

As shown in Figure 2, the data link relays target sensor data to range control and display, while the command link relays target commands from range control to the target complex.

The data link and the command link can use single-channel transmission. It is quite possible that channel assignments for such a data transmission system will be in the lower portion of S-band (about 1750 MH_z). The required band-width of each link will depend on the instrumentation of the target complex. It is safe to assume the required data link band-width will be less than 20 kHz and that of the command link considerably less -- perhaps 1 kHz.

The data and commands will have a digital format. The accuracy of the data and command links is guaranteed by establishing transmitter power levels to ensure a 30db signal-to-noise ratio (S/N) at the input to the detector or each receiver. This value of S/N will guarantee a bit error rate less than 10^{-5}.

Power limitations, particularly at the target complex, and reliability and transportability considerations require that good design practices be followed in specifying and fabricating the receiver and transmitter units. Within the transmitter-receiver package at the target complex, there will be duplexer to permit operation of the transmitter and receiver in a two-way simulaneous system. This same package is useable at the central site to receive signals from the target complex and to drive the central site power amplifier.

The central site will use horn antennas for both transmission and reception. Where necessary, the antennas can be mounted on a tower (up to about 50 feet in height) to provide line-of-sight conditions between the target complex antenna and the central site antennas.

Several factors require consideration in specifying the type of modulation. These include ease of modulation and demodulation, power amplifier linearity requirements; system bandwidth, and multipath effects.

Frequency shift keying (FSK) has been a popular choice of modulation because of the simplicity and reliability of modulation and demodulation circuits. For example, a voltage-controlled astable multivibrator is a simple, reliable, versatile frequency modulator. For demodulation of an FSK signal, conventional ratio detectors can be used.

Somewhat more complicated but more versatile and accurate than a ratio detector is a pulse-counting discriminator (boxcar detector).

Phase-reversal modulation is worthy of consideration because of new, simple techniques of modulation and demodulation. Further, theory indicates, and experimental results confirm, that phase-reversal modulation is an optimum form of digital data transmission in the sense that it provides minimum error probability for a given value of signal-to-noise ratio.

Because of the general availability of components and subsystems designed for use with systems using FSK modulation, special attention in the study should be given to use of FSK. The techniques for handling FSK signals are well-known and can be easily understood by operational and maintenance personnel with a minimum of specialized education or training.

For purpose of analysis, the range of the communication (data and commands) link is assumed to be 5 miles (line-of-sight path). For a signal-to-noise ratio of 30 db and a bandwidth of 20 kHz, the required transmitter power can be calculated as follows:

Data Channel RF link calculation:

Target complex duplexor and cable loss	2.5 db
Transmitter antenna gain (half-wave dipole)	1.2 db
Path loss at 1750 MH_Z (5 miles, free space)	116.0 db
Receiver antenna gain (horn)	14.0 db
Receiver cable loss	.5 db
Receiver noise level (20 kHz bandwidth)	131.0 dbm
Receiver noise figure	8.0 db
Carrier-to-noise ratio required	30.0 db

For these conditions, the required received signal power P_r is -131 dbm + 8 db + 30 db = -93 dbm. The required

transmitter power P_t is -93 dbm plus an additional amount to overcome the losses minus system gain. Therefore, P_t = - 93 dbm + 2.5 db - 1.2 db _ 116 db - 14 db + 0.5 db = +10.8 dbm or 10 m watts.

In the above calculations, the path loss α was determined by using the standard, well-known formula:

$$\alpha \text{ in db} = 37 + 20 \log f + 20 \log d$$

where f is carrier frequency in MH_z and d is distance in miles. Setting f = 1750 and d = 5 gives α = 116.

The receiver noise level P_n in watts is given by:

$$P_n = kTB \text{ watts} = kTB \times 10^3 \text{ m watts}$$

where

k = Boltzmann's constant - 1.38×10^{-23} joules/degree Kelvin.

T = absolute temperature in degrees Kelvin - 293° assumed (room temperature).

B = bandwidth in Hz = 2×10^4 assumed.

In dbm, $P_n' = 10 \log (kTB \times 10^3) = 131$ dbm.

From this calculation, a 10 milliwatt transmitter at the target complex is considered adequate for the range-scoring system.

Calculations for the command link proceed in a like manner. The transmitter power required will be less than for the data link because of the reduced command link bandwidth.

In general, the range of a microwave communications system increases with the height of the antenna above the surrounding terrain. For this reason, and to achieve more nearly line-of-sight transmission at a variety of locations, the central site should have a provision for an antenna tower whose height will be dictated by terrain considerations.

The transmitting and receiving antennas can be identical units spaced about three feet apart on the tower. Horn antennas with a 20° elevation plane and a 30° azimuthal beamwidth should be considered. These vertically polarized antennas are approximately 15 inches (H-plane) by 22 inches (E-plane) by 24 inches long and have a midband gain in excess of 14 db. This antenna is more efficient, less complex, less expensive than a parabolic antenna.

A low-noise preamplifier will be located on the tower near the receiving antenna to minimize the effect of cable loss, thereby improving system sensitivity. To protect the amplifier from the strong transmitter signals, a bandpass filter is placed between it and the receiving antenna. The antenna complex, therefore, will include the tower, transmitting antenna, receiving antenna, preamplifier, and bandpass filter.

The target complex communications equipment both transmits and receives signals. Outputs from the target transducers are encoded into a two-level digital format (code word) which becomes the carrier modulating signal. The modulated carrier will be frequency multiplied, amplified, and

delivered to a dipole antenna for transmission. The command signals from the central site will be received by the common dipole antenna, demodulated, decoded, and routed to the appropriate target actuating mechanisms.

The antenna at the target complex should be compatible with the severe environment and be as inconspicuous as possible. One feasible approach is to minimize antenna size, which will have the further advantage of a low probability of being hit by projectiles.

CONTROL AND DISPLAY

The central control and display system will be utilized to control the presentation of targets and simulator fire and to monitor general range operation. Targets may be controlled manually or by computer command tapes. Not only must hits and near misses be displayed at the center, but there is also a requirement that there be displays or range status sufficient to permit the range officer to effectively control the range from a remote location. Adequate communications must be maintained with the weapon crew and test observers.

Numerous display devices are available, ranging from simple readouts of round counts, target status, and location and hit data to elaborate computer driven CRT displays. The decisive factors in selecting display equipment will be cost and the requirements imposed by target sensor and data links.

The central control and display subsystem should provide for accumulating, displaying, and storing hit and near-miss data. Additionally, it must provide a means for

controlling the entire firing exercise, to include target area presentations, simulator fire control, and crew performance monitoring.

The requirement for a digital computer would, of necessity, be dependent on incoming data characteristics and rates as well as processing requirements. Should analysis of these parameters show that a digital computer is not required, several display options are available to include a topographical display readout of target hits. Multi-channel recorders may be used to record telemetered or land line data which would be correlated with other required range events.

A small or medium size digital computer could accept all incoming data, record it on a permanent record and be coupled to display devices of various types. An analysis of the required incoming data character rates as well as display requirements would dictate the computer size and processing capabilities.

The display subsystem, controlled by the computer, could consist of topographical range layouts coupled with lighted target positions and direct digital readout of total hits, misses, or other required target events received at the control computer. It shall be noted that this display technique would not necessarily require a computer. Instead of, or in addition to, the above display, a large CRT (cathode ray tube) display of target positions and weapon emplacement could be directly coupled to the digital computer. Further, digital computer could simultaneously record this video output utilizing a video recorder, permitting a post test rerun of CRT display as recorded during the run. All recorded data would be available for post test analysis and/or crew debriefing.

Section 7

RANGE SUPPORT SOFTWARE

If data requirements dictate the use of a computer in conjunction with the anti-tank weapons test range, it will be necessary to design and implement support software to perform a variety of functions. These will include, but not necessarily be limited to the following:

1. Master control
2. Interrupt monitor
3. Display drivers
4. Command generation
5. Data correlation and analysis

A brief description of each of the above will be presented in the following paragraphs.

1. Master Control

As its name implies, the Master Control (MC) program provides overall control of test support software during execution. Specifically, MC initiates and controls task sequences, loads programs and data sets from a master file (tape or disc), provides a central input/output function, allocates storage, and generates error alarms.

2. Interrupt Monitor

During the conduct of an anti-tank weapons test, the computer will be programmed to service inputs from the range instrumentation system as they occur. This will be accomplished by the use of interrupts, which transfer

control to the appropriate service subroutine via MC immediately upon arrival. The service subroutine processes the incoming data, returning control to the interrupted program upon completion. It may be necessary to establish a priority interrupt system in which lower priority service requests are queued to avoid interrupting critical sequences. A block diagram of the Interrupt Monitor (IM) and its interface with MC is shown in Figure 3.

Queued programs will be processed in priority sequence upon completion of the highest priority program, under control of MC, as shown in Figure 4.

3. Display Drivers

The display programs convert and format test data for presentation at the data collection center. The precise specifications for these subroutines will be dependent upon the characteristics of the display units at the center.

4. Command Generation

The function of the command generation program will be to prepare digital data for transmission to the target complex via command link. If the scenario calls for conditional execution of commands (e.g., stop when hit), the command generation programs will be an integral part of the real-time support system.

5. Data Correlation

This category encompasses a set of programs to be used primarily in post-exercise analysis of test results, and would include a standard set of statistical procedures, sorting, collating, and time-tagging programs and report generators.

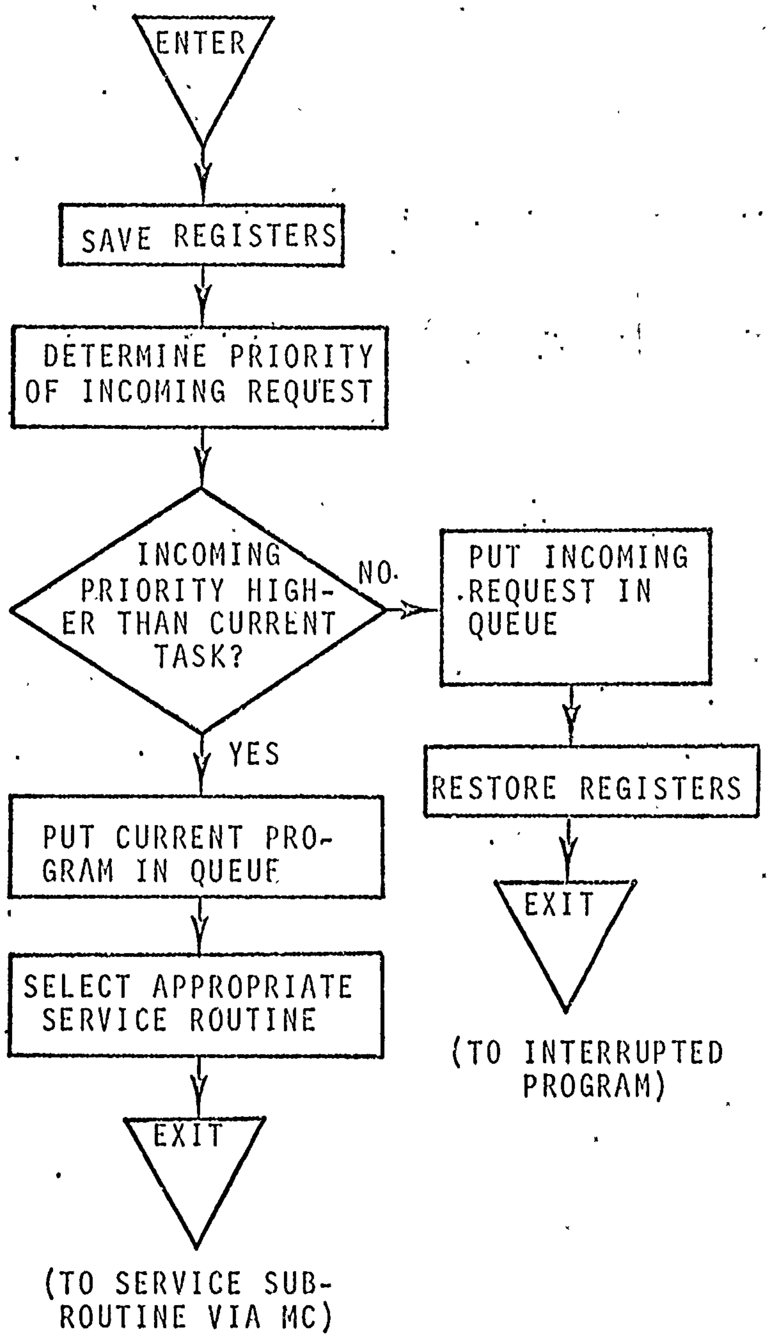


Figure 3. Interrupt Monitor

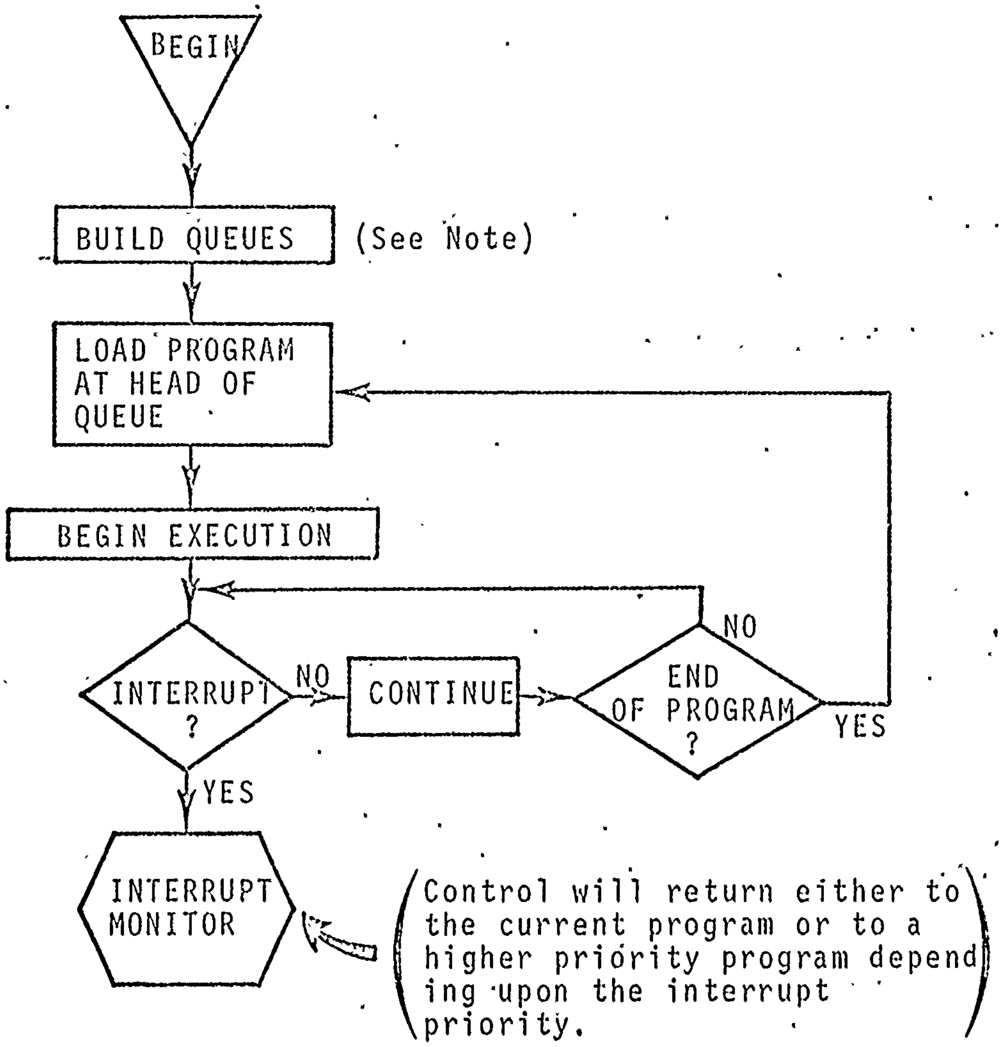


Figure 4. Queue Processing

Note: The initial queue will consist of the nominal task sequence.

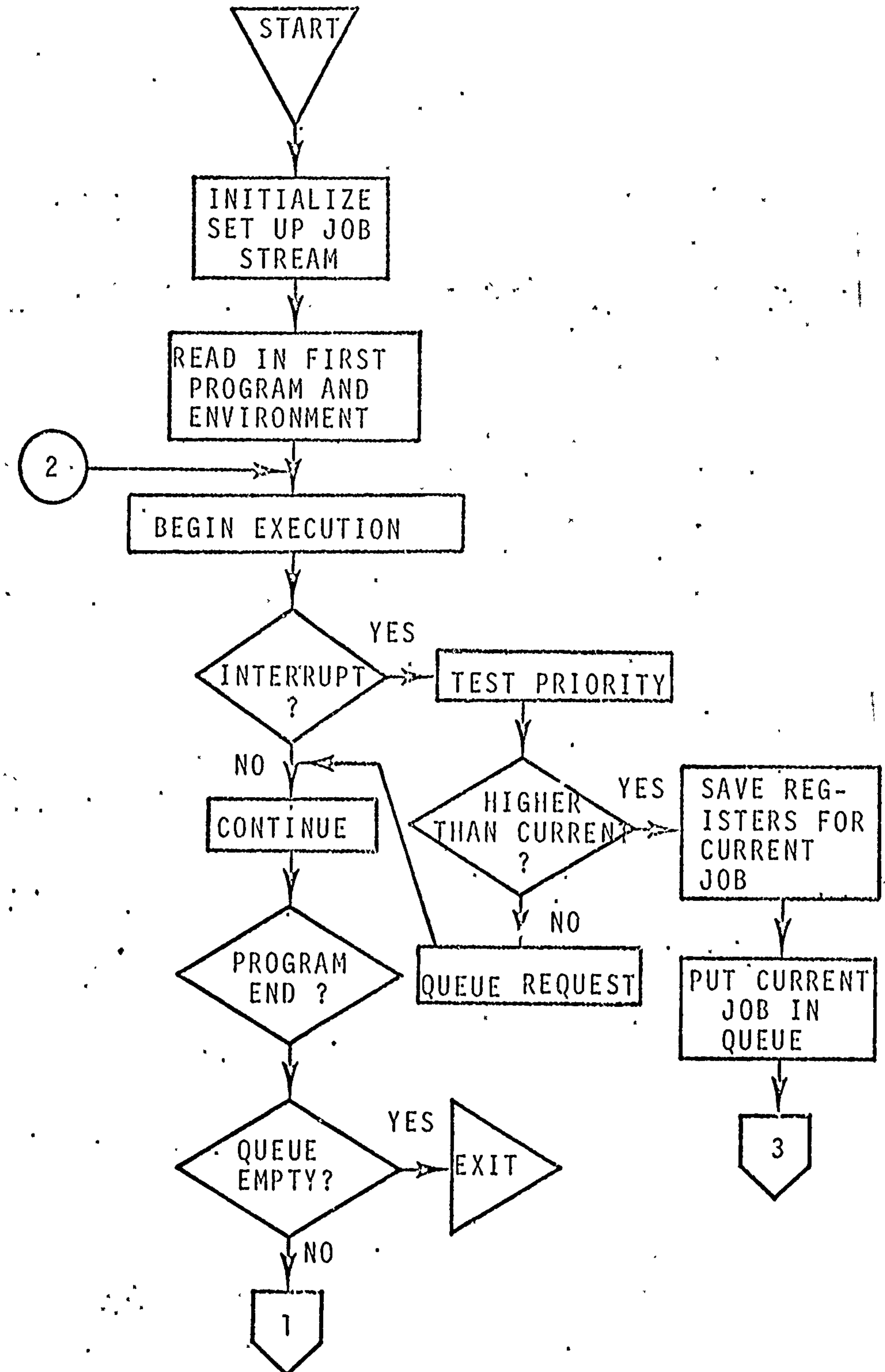


Figure 5 . Overall Program Flow

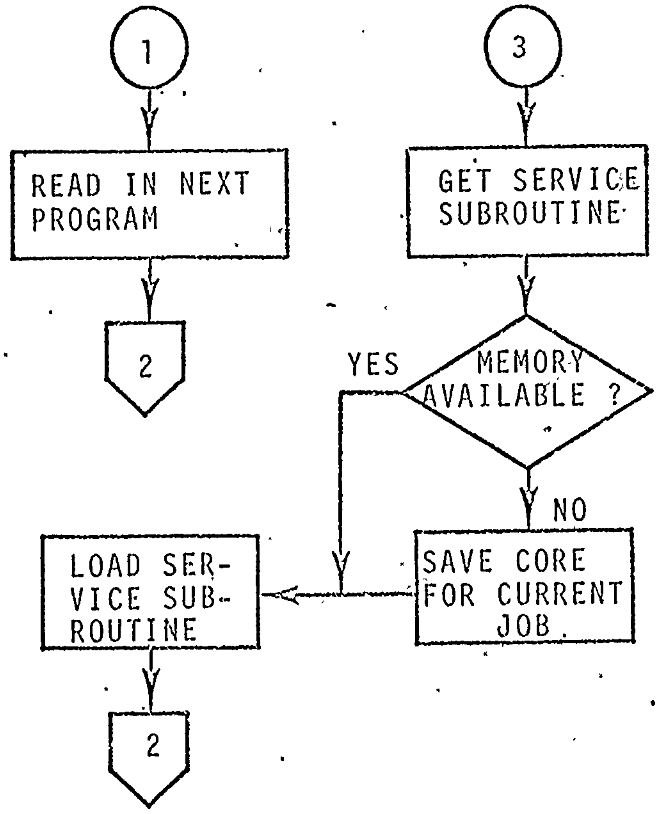


Figure 5. (Cont'd) Overall Program Flow.

Annex A

BIBLIOGRAPHY

1. Maximum Anti-Tank Range Study, (U), June 1963, Advanced Sensors Laboratory, Army Missile Command, Redstone Arsenal, Alabama. AD 344 545 L (Confidential, limited).

2. Project Pinpoint, Disclosure of Anti-Tank Weapons to Over-Watching Tanks, Technical Memorandum ORO-T-362, Operations Research Office, Johns Hopkins University, Bethesda, Md. (Unclassified).

3. The Range and Angular Distribution of A.P. Hits on Tanks, December 1951, Ballistic Research Laboratories Aberdeen Proving Grounds, Md. (Confidential).

4. Vulnerability of Tanks to Infantry Anti-Tank Weapons (U), G.A. Ziller, May 1958, Ballistic Research Laboratories, Aberdeen Proving Grounds, Md. (Confidential).

5. The TOW Heavy Assault Weapon System -- Paper Presented to NATO Committee AC 172, (U), April 1963, BRL-MR-1482, Ballistic Research Laboratories, Aberdeen Proving Ground, Md., AD 340 362 (Secret).

6. Optimum Characteristics of Man-Portable Anti-Tank Weapons, (U), Operations Research Office, John Hopkins University, Bethesda, Md. (Confidential).

7. Accuracy and Time of Flight of Shell, WP-T, T269E16, for 106MM Recoilless Rifle, M40A1, J.C. Moore, September 1959, Aberdeen Proving Ground, Md.

8. An Analysis of Factors Which Influence Tank and Anti-Tank Engagement Ranges - CORG., February 1962, AD 371 815.

9. Anti-Tank Guided Weapons, An Initial Estimate of Performance Under Operational Conditions - Royal Armaments Research and Development Establishment (B) 42/63, AD 340 343.

10. Effectiveness Study of Infantry Anti-Tank Weapons; Lepold and Yates, August 1968. Technical Memorandum #13, Weapons Systems Division, Army Materiel Systems Analyzing Agency, Aberdeen Proving Ground (C), AD 392 365.

11. Gunner's Aiming Errors in Anti-Tank Weapons; Robert T. Gschwind, February 1964. Human Engineering Labs, Aberdeen Proving Ground, Md. (c), AD 351 392.

12. Influence of Terrain and Tactics on the Range of Direct Fire Anti-Tank Weapons - ARDE Report (B) 5/58, AD 159 525.

13. Analysis of Infantry, Tank, and Anti-Tank Weapons Performance Data, Robert L. Gardner, et.al., December 1967. HRB-Singer, State College, P.A. (S), AD 394 076.

14. First Round Hit Probability for Free Flight Anti-Tank Weapons with Simple Sight; Arthur D. Groves, June 1965, BRL-MR-1661, Ballistic Research Labs, Aberdeen Proving Ground, AD 470 485.

15. Survey of Small Missile Control Techniques, Final Report, 1 Feb. - 30 Sept. 1967, Graham W. Casserly, Nov. 1968, Institute of Science and Technology, Michigan University, Ann Arbor, Michigan (C), AD 394 291.

16. Infantry Assault/Anti-Tank Weapons, 20 September 1962, Department of Navy, Hq. U.S. Marine Corps, AD 394 498.

17. Ballistic Investigation of Ammunition Components used for Acceptance of 106MM, M40A1 Recoilless Rifles; J.C. Moore, Aug. 1960, Aberdeen Proving Ground, Md. AD 241 318 (U).

18. TIR 33.2.1.20, Night Sight for TOW Missile System; (U), Jan. 1969, By Research Division, Governmental Affairs Institute, Washington, D.C., for Army Material Command, Washington, D.C. AD 500 944 L (Confidential, Limited).

19. TM 9-100-205-12, Operator and Organizational Maintenance Manual, 106MM Recoilless Rifle, M40A1 with Cal. .50 Spotting Gun M8C on Mount M79 or M92 with Tripod M27, and 106MM Recoilless Rifle M40A1C used on Multiple 106MM Ft. SP. Rifle M50; Mar. 1959, with Change 2., Oct. 1965 Hq., D.A., Washington, D.C. (Unclassified).

20. TM 11-5855-202-13, Organizational and DS Maintenance Manual, Night Vision Sight - Crew Served Weapons, Models 9927 and 9927A; Apr. 1967, Hq., D.A., Washington, D.C. (Unclassified).

21. Conduct-of-Fire Training Set, XM70, for TOW Missile System; (U), Interim Report, Aug. 1968, Research Div., Governmental Affairs Institute, Washington, D.C. AD 394 419 L (Confidential, Limited).

22. A Subj. SCD. 7-3, Weapons Squad Tactical Training; 1 April 1966, D.A., Washington, D.C.

23. A Subj. SCD. 7-8, Anti-Tank Squad and Section Tactical Training, 8 Dec. 1961, D.A., Washington, D.C.

24. A Subj. SCD. 23-36, Combat Firing, 2 Jun. 1964, D.A., Washington, D.C.

25. A Subj. SCD. 7-35, Anti-Tank Platoon Tactical Exercises, 28 Apr. 1967, Hq., D.A., Washington, D.C.

26. Effects of Terrain on Battlefield Visibility; (U), D.F. Bayly Pike and Charles F. Goepel, Aug. 1962, ORO-T-161, John Hopkins University, Chevy Chase, Md. (C66-1687).

27. Analysis of Terrain Data with Respect to Intervisibility; Apr. 1966, Operational Research Div., Dept. of National Defense, Washington, D.C. (Confidential).

28. Brightness Thresholds as a Function of Target Contrast and Retinal Position; 11 Jul. 1955, U.S. Naval Bureau of Medicine and Surgery (U66-1176).

29. Methods used at U.S. Ballistic Research Laboratories for Evaluation of Tanks and Anti-Tank Weapons in the Anti-Tank Role; (U), Mar. 1963. BRL. Memo Rept. No. 1455, Aberdeen Proving Ground, Md.

30. Tank, Anti-Tank and Assault Weapons Requirements Study; Phase III, Vol. V, App. I and II to Annex F, (U), Final Draft, Dec. 1968, Army Combat Developments Command, Fort Belvoir, Va. AD 500 594 L (Secret Limited)

31. Tank, Anti-Tank and Assault Weapons Requirements Study; Phase III, Vol. XI, Annex L, App. 1 to Annex L, (U) Final Draft, Dec. 1968, Army Combat Developments Command, Fort Belvoir, Va. AD 500 634 L (Secret, Limited).

32. A Cost-Effectiveness Evaluation of TOW; (U), R.L. Simmons, et.al., Apr. 1965, BRL-TN-1559, Ballistic Research Labs., Aberdeen Proving Ground, Md. AD 361 278 (Secret).

33. Stress, Institute for Defense Analysis; R and E Support Division, Dr. Joseph Weitz, April 1956.

34. Military Small Group Performance Under Isolation and Stress; Critical Review, U.S. Department of Commerce, June 1962 (U66-1231).

35. The Construction, Validation, and Application of a Subjective Stress Scale; H. Kerle and H.M. Bialek, 1958.

36. Perception Under Stress; Psychological Review, Volume 55, Pages 314-323, Postman and Bruner, 1948.

37. Recall of Completed and Incompleted Activities Under Varying Degress of Stress, Journal of Experimental Psychology, Volume 39, Pages 281-295, A.F. Gillmann, 1949.

HUMAN FACTORS

Human factors considerations pertinent to the conduct of weapons systems testing fall into several broad categories which will be treated in this section. These are individual proficiency, unit proficiency, combat realism (and the imposition of stress), and motivation. Generally, these factors are not as subject to rigid experimental control as are other aspects of test procedures, so it will be necessary to design means of minimizing or correcting for bias in test data resulting from them.

1. Individual Proficiency

Test personnel in each category should be close to the norm in proficiency for that specialty, and should be representative of the proficiency level which could be expected of field combat troops. Selection should be bases on such objective criteria as, MOS, experience in MOS and proficiency, and duration and nature of combat experience.

2. Unit Proficiency

The proficiency of a group of test personnel should be assessed and compared with established norms before conducting tests. This is particularly essential in comparative testing of complex weapons systems (e.g., TOW) in which minor differences in operator efficiency can vitally affect test results. Leadership should be assessed in conjunction with evaluating unit proficiency, particularly in test situations which will require decision-making under extreme time constraints.

Uniformity in proficiency will generally be enhanced by subjecting the units to a modified and abbreviated Army Training Test (ATT) and correcting any noted deficiencies before conducting tests.

3. Combat Realism and Stress

Introduction of combat realism into a test environment is recognized as a major problem to which no completely satisfactory solution has been found. Simply stated, no adequate method has been devised to present the test subject with a credible threat to his life in a simulated combat situation wherein only the subject's side employs live fire. Hence, the basic motivations of individual and unit survival may be largely absent and must be replaced by alternates. Possible alternatives will be discussed in the following section.

The combat environment, in terms of auditory and visual stimuli, can be approximated to any degree desired, cost being the major determinant. In particular, return fire from the target can be simulated, as can the smoke and dust typical of an engagement.

Generally, stress can be introduced by requiring the subject to conduct monotonous and repetitive tasks in the presence of constant distractions, by requiring the performance of complex tasks under severe time constraints, by requiring decisions in the presence of excessive and often irrelevant information inputs (information overload), and by sleep deprivation. Test scenarios should employ such techniques to enhance the validity of test results.

4. Motivation

As discussed previously, the motivation of survival cannot be duplicated without actually subjecting the subject to a

threat to his life. Therefore, other means of motivating these test subject must be explored. Field tests with prolonged and repetitive trials tend to induce apathy and fatigue among the subjects, and unless the motivation levels are controlled unacceptable variations in group performance may result.

Motivation can be introduced by creating a gain-or-loss situation wherein the subject gains or loses depending on the quality of his performance. References in these areas are given in the Annex A, Bibliography (items 33-37).

Any feasible motivational scheme requires a scoring system in which the subject is quickly aware of the consequences of his actions. Thus, informed, he will modify his future actions, becoming goal-directed and generally improving his performance. It should be stressed, however, that the scoring and reward/punishment schemes should not be allowed to become a "game" in themselves and to obscure the overall test objective.

GLOSSARY AND DEFINITIONS

ATGM - Anti-Tank Guided Missile.

Beacon - A radio frequency transmitter mounted on a mobile object to facilitate tracking by remote antennas.

Boresight - Device used to align the axis of the bore of a gun with an aiming point (AR 320-5).

Boresighting - Process by which the axis of a weapon and/or antenna is aligned optically or electronically to be parallel with or to specified convergence with the line of sight of its associated sighting instruments (AR 320-5).

Direct Fire - Gunfire or missile launch delivered on a target, using the target itself as a point of aim for either the guns or the director (AR 320-5).

Effective Range - The maximum distance at which a weapon may be expected to fire accurately to inflict casualties or damage (AR 320-5).

F-kill - A hit or hits on target which disable the tank's guns.

Guided Missile - An unmanned vehicle moving above the surface of the earth, whose trajectory or flight path is capable of being altered by an external or internal mechanism (AR 320-5).

HAW - Heavy Assault Weapon (See TOW).

Hitskin - A target material manufactured by Joanell Corporation employing parallel electrical grids imbedded in plastic as a means of detecting and locating projectile penetration.

LAW - Light Assault Weapon.

M-kill - A hit or hits on target which immobilize the tank.

MAW - Medium Assault Weapon.

Operational Evaluation - The test and analysis of a specific end item or system, as far as practicable under service operating conditions, in order to determine if quantity production is warranted considering (a) the increase in military effectiveness to be gained, and (b) its effectiveness as compared with currently available items or systems, consideration being given to (1) personnel capabilities to maintain and operate the equipment and (2) size, weight, and location considerations, and (3) enemy capabilities in the field. (AR 320-5).

P_k - Kill Probability - (See definitions of M-kill and F-kill).

Recoilless - Term applied to certain weapons employing high velocity gas ports (jets) to counteract recoil. (AR 320-5).

Recoilless Rifle - Projectile firing weapon in which the rearward movement resulting from firing is essentially eliminated. (AR 320-5).

Recoilless Rifle (Heavy) - A weapon capable of being fired from either a ground mount or from a vehicle and capable of destroying tanks. (AR 320-5).

Recoilless Rifle Operation - The recoilless ammunition cartridge case is perforated to permit expanding gases of ignited propellant powder to escape evenly into the enlarged reaction chamber. These gases exert equal pressure in all directions within the chamber. Pressure to the front against the sloping wall of the chamber equals the force to the rear against closed portions of the breech. The remainder of the force exerted by the gases causes a conventional weapon to recoil. In a recoilless rifle, the remaining gases are permitted to excape to the rear through openings in the breech. Therefore, the rifle remains motionless when fired. (FM 23-82).

Reliability - The probability of a device performing its mission adequately for the period of time intended under the operating conditions expected to be encountered.

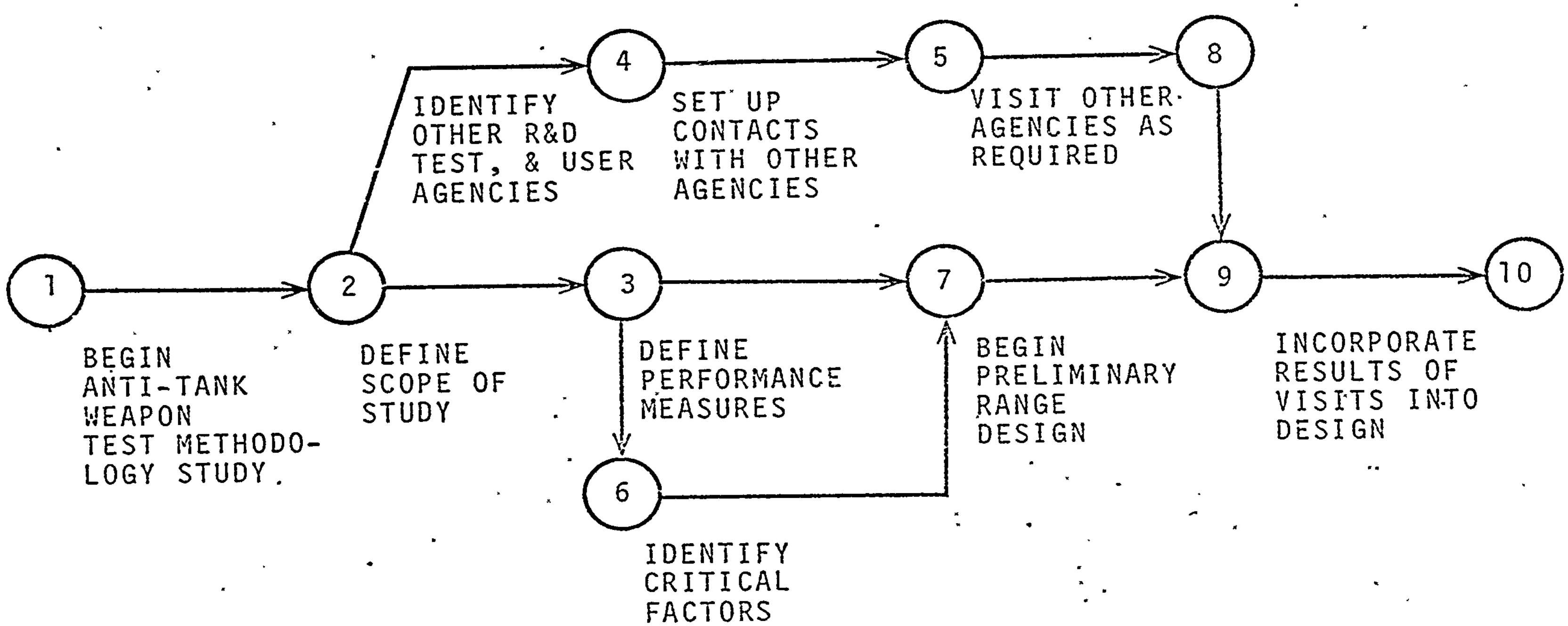
Spotting Gun - A gas operated, air-cooled, magazine-fed, semi-automatic weapon designed to assist the gunner in determining range and leads to the target, firing special caliber spotting ammunition. (FM 23-82).

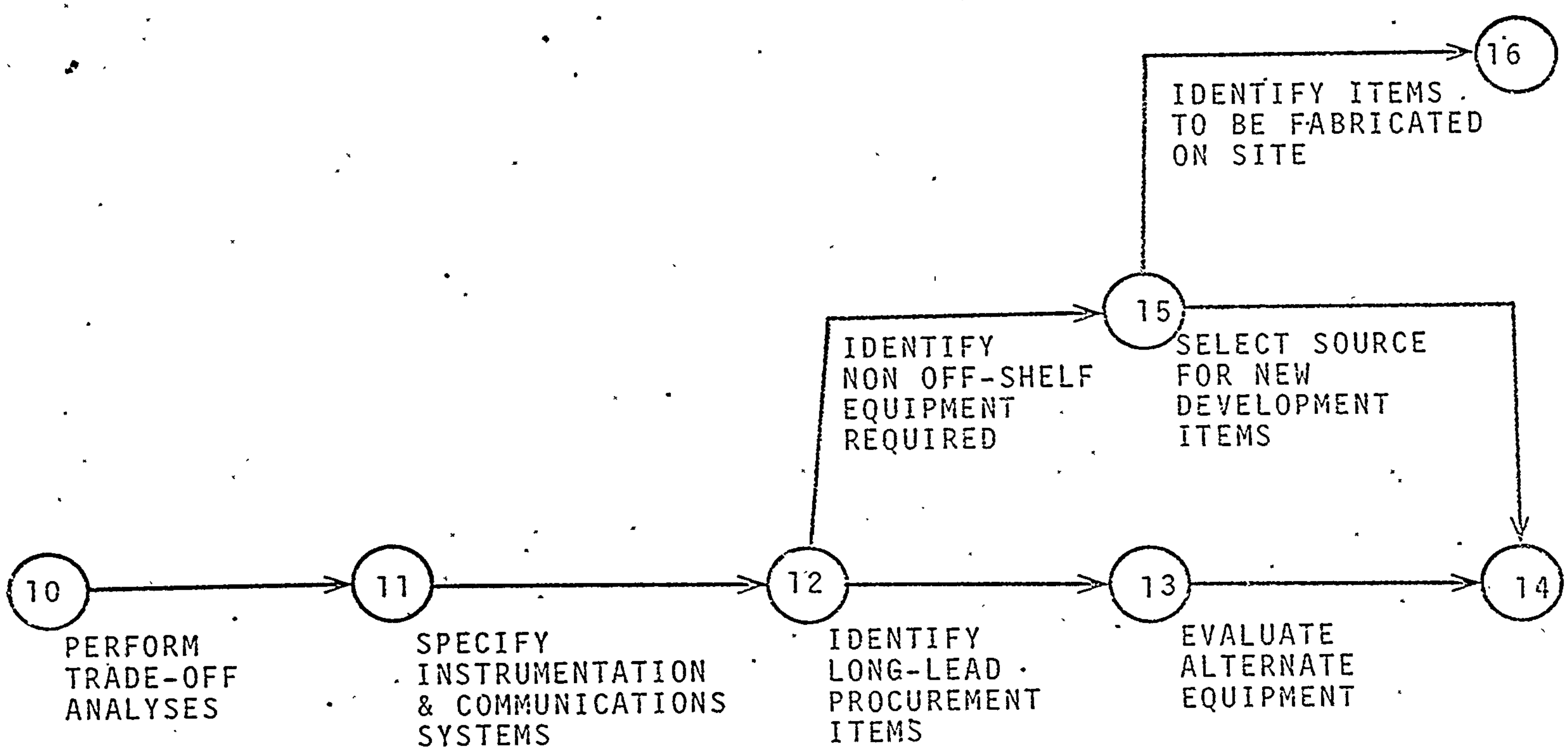
TOW - Tube launched Optically tracked, Wire-commanded missile system.

Annex D

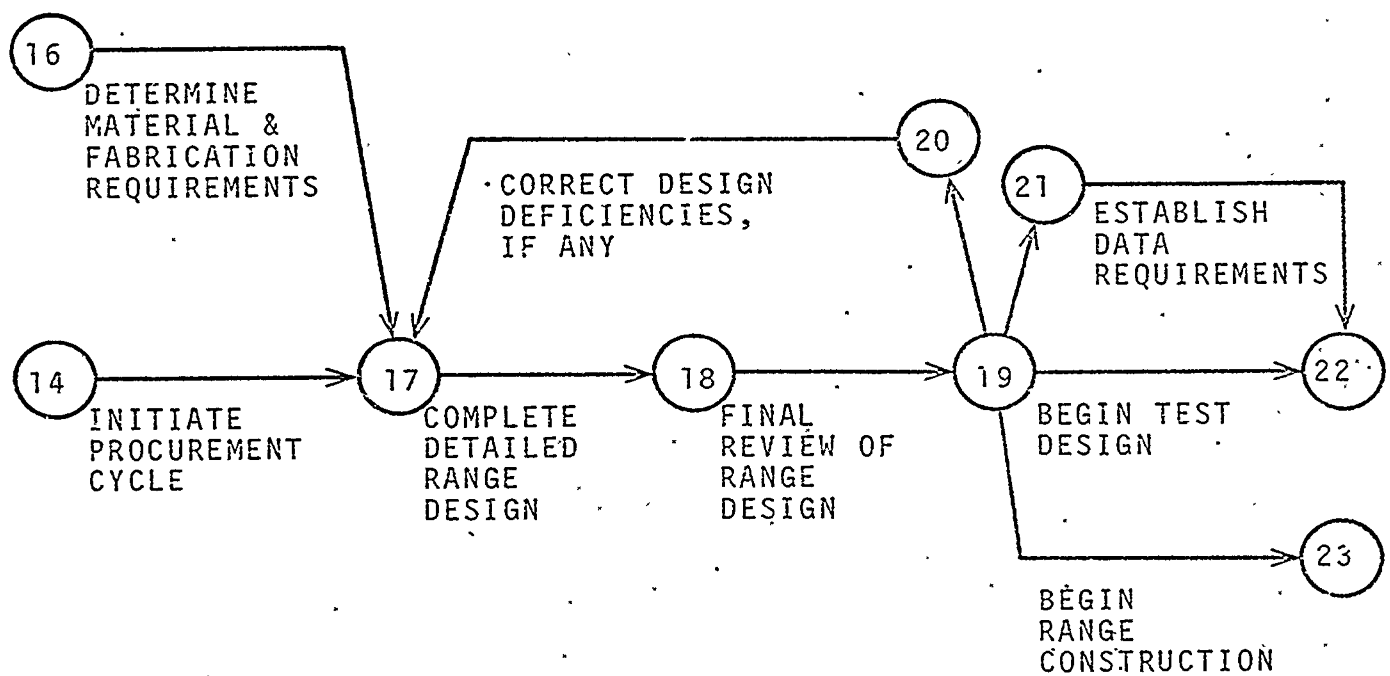
PERT ANALYSIS

The following pages present a summary PERT analysis of the anti-tank weapons test methodology study, leading to the establishment of an anti-tank weapons test range, the conduct of weapons tests under quasi-combat conditions, and the preparation of a final report on the first of a series of tests to be conducted on the range.

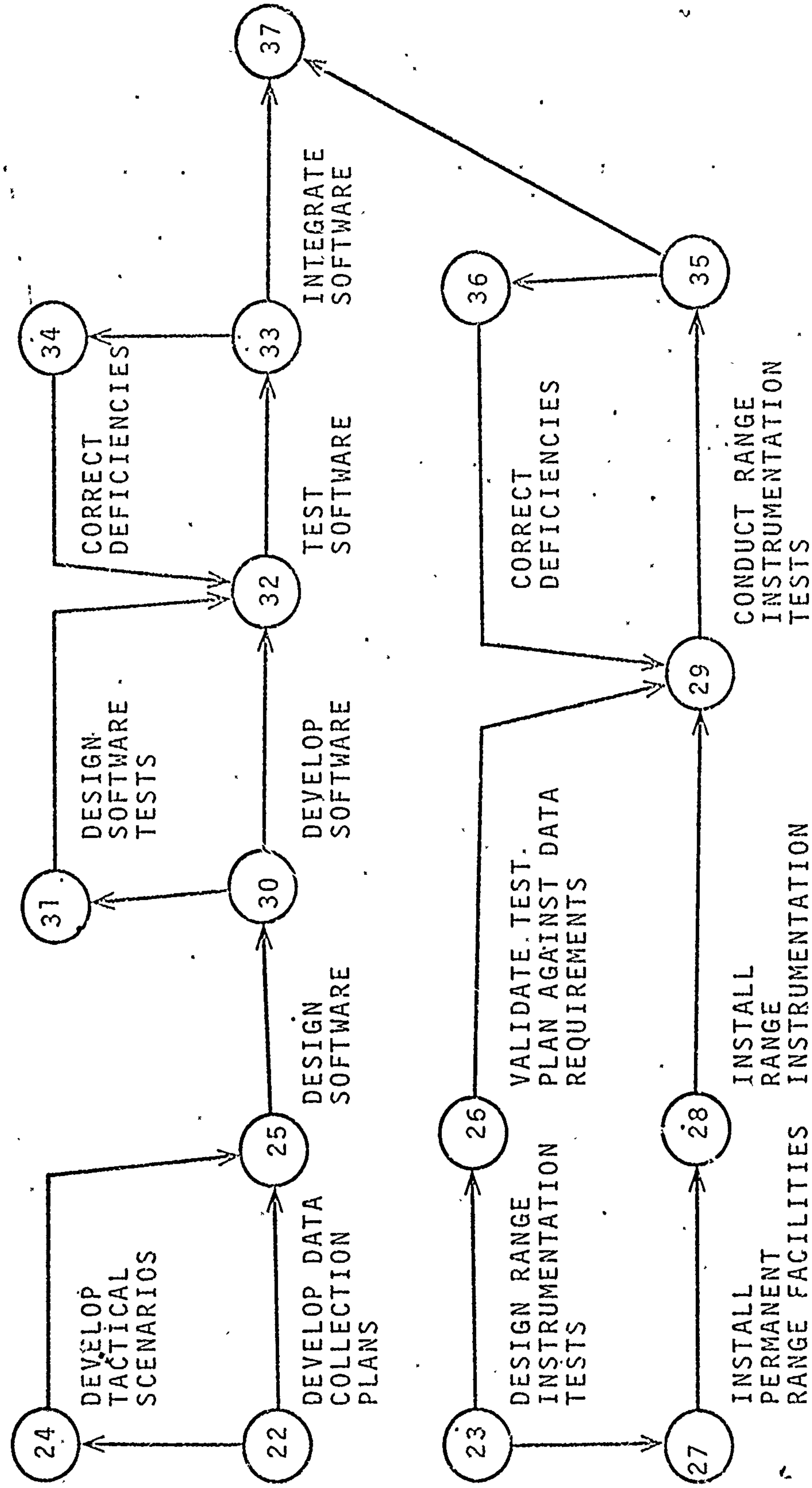

1
BEGIN ANTI-TANK WEAPON TEST METHODOLOGY STUDY.
2
DEFINE SCOPE OF STUDY
IDENTIFY OTHER R&D TEST, & USER AGENCIES
4
SET UP CONTACTS WITH OTHER AGENCIES
5
VISIT OTHER AGENCIES AS REQUIRED
8
3
DEFINE PERFORMANCE MEASURES
6
IDENTIFY CRITICAL FACTORS
7
BEGIN PRELIMINARY RANGE DESIGN
9
INCORPORATE RESULTS OF VISITS INTO DESIGN
10



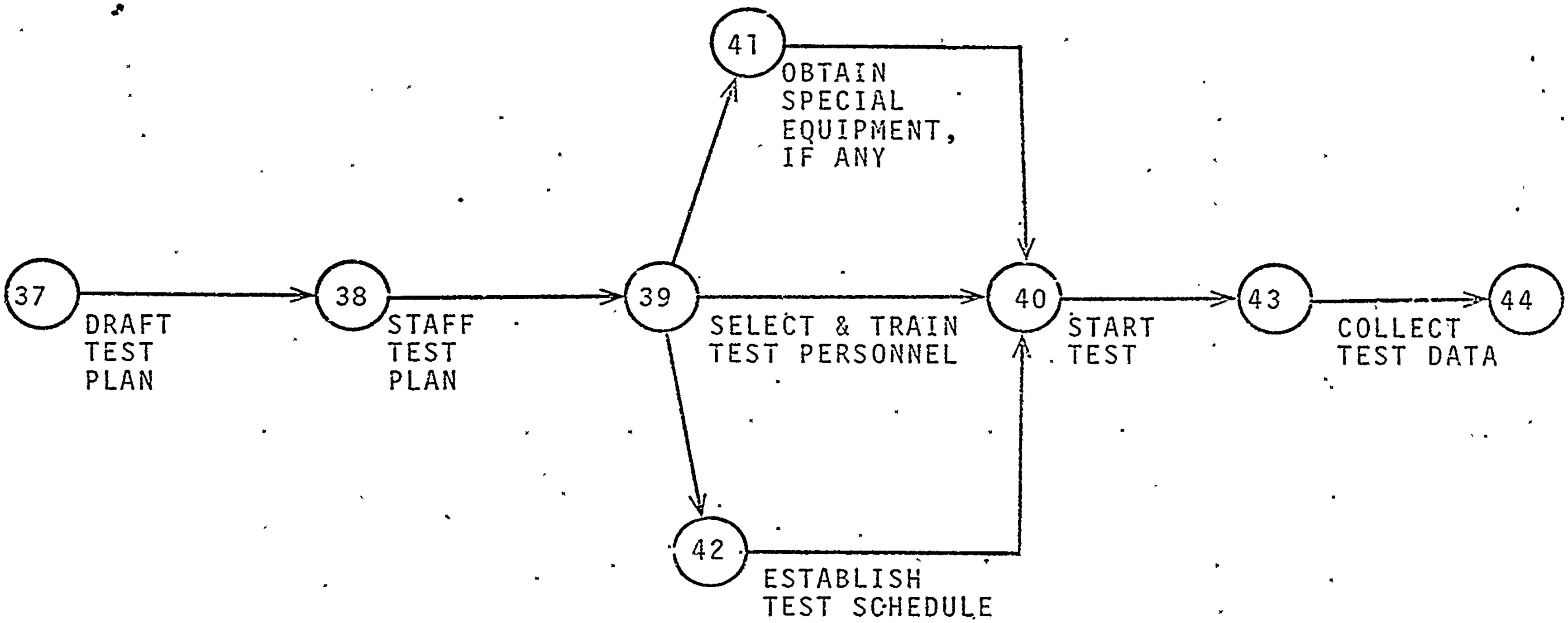
16
IDENTIFY ITEMS TO BE FABRICATED ON SITE
15
SELECT SOURCE FOR NEW DEVELOPMENT ITEMS
IDENTIFY NON OFF-SHELF EQUIPMENT REQUIRED
10
PERFORM TRADE-OFF ANALYSES
11
SPECIFY INSTRUMENTATION & COMMUNICATIONS SYSTEMS
12
IDENTIFY LONG-LEAD PROCUREMENT ITEMS
13
EVALUATE ALTERNATE EQUIPMENT
14

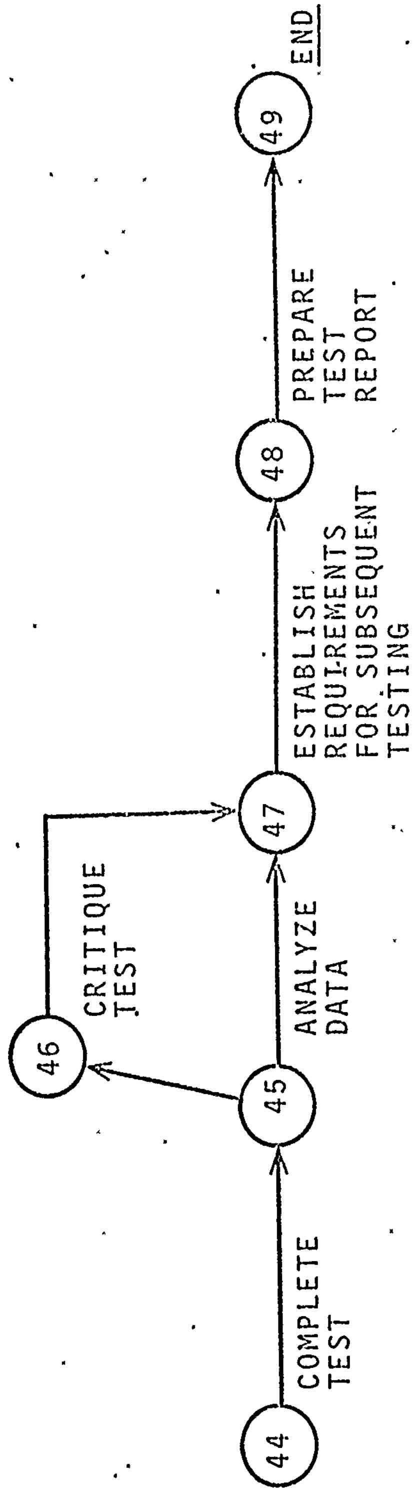


16
DETERMINE MATERIAL & FABRICATION REQUIREMENTS
14
INITIATE PROCUREMENT CYCLE
17
COMPLETE DETAILED RANGE DESIGN
18
FINAL REVIEW OF RANGE DESIGN
19
20
CORRECT DESIGN DEFICIENCIES, IF ANY
21
ESTABLISH DATA REQUIREMENTS
22
BEGIN TEST DESIGN
23
BEGIN RANGE CONSTRUCTION



22
24
25
DEVELOP TACTICAL SCENARIOS
DEVELOP DATA COLLECTION PLANS
DESIGN SOFTWARE
30
31
DESIGN SOFTWARE TESTS
DEVELOP SOFTWARE
32
CORRECT DEFICIENCIES
TEST SOFTWARE
33
34
INTEGRATE SOFTWARE
37
23
26
27
28
DESIGN RANGE INSTRUMENTATION TESTS
VALIDATE TEST PLAN AGAINST DATA REQUIREMENTS
INSTALL PERMANENT RANGE FACILITIES
INSTALL RANGE INSTRUMENTATION
29
CORRECT DEFICIENCIES
CONDUCT RANGE INSTRUMENTATION TESTS
35
36


37
DRAFT TEST PLAN
38
STAFF TEST PLAN
39
SELECT & TRAIN TEST PERSONNEL
41
OBTAIN SPECIAL EQUIPMENT, IF ANY
42
ESTABLISH TEST SCHEDULE
40
START TEST
43
COLLECT TEST DATA
44



44
COMPLETE TEST
45
ANALYZE DATA
46
CRITIQUE TEST
47
ESTABLISH REQUIREMENTS FOR SUBSEQUENT TESTING
48
PREPARE TEST REPORT
49
END

APPENDIX II

ANTITANK WEAPONS METHODOLOGY REVIEW

AD________________________________

USATECOM PROJECT NO 8-5-0070-01

USAIB PROJECT NO 3091

INFANTRY WEAPONS TEST METHODOLOGY STUDY

INFANTRY ANTITANK WEAPONS
METHODOLOGY REVIEW

FINAL REPORT

July 1970

UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

AD______________________________

USATECOM PROJECT NO 8-5-0070-01

USAIB PROJECT NO 3091

INFANTRY WEAPONS TEST METHODOLOGY STUDY

INFANTRY ANTITANK WEAPONS
METHODOLOGY REVIEW

FINAL REPORT

July 1970

UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

ABSTRACT

The Infantry Board is engaged in a five year Infantry Weapons Test Methodology Study. Antitank weapon systems were addressed in this study and this review outlines the analytical approach undertaken. The review discusses the interaction of combat actions and combat tasks as well as categories of effectiveness. Representative combat actions are selected and definitive measures of effectiveness (MOE) are presented.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

STEBC-CT

INFANTRY ANTITANK WEAPONS METHODOLOGY REVIEW

1. PROBLEM. To validate, through the consideration of Infantry combat actions and the resulting characteristic individual weapon performance or actions, the measurements that will permit discriminations to be made between competing antitank weapons systems. These measurements should provide discriminations between competing weapons systems. Conclusions and recommendations are desired.

2. ASSUMPTIONS.

a. Current doctrine concerning the mission, employment, and role of the antitank weapon and crew in combat will not materially change in the near future.

b. Weapons tested on the to-be-developed range(s) will continue to fire a solid projectile or missile.

c. Sufficiently qualified test officers and scientific and engineering specialists are available within the Infantry Board to conduct weapons systems evaluations and tests efficiently and to reduce and analyze the collected data.

d. Current weapon development will continue to experience only small differences between competing antitank weapons systems.

and training literature (Annex I). As a result of this research 24 separate combat actions were identified and listed.

c. A list of the various critical tasks normally accomplished by the individual/crew when executing the combat actions listed in Annex B was prepared after further researching all of the pertinent doctrinal and training literature. As a result of this further study, 13 separate critical combat tasks were identified and listed (Annex C).

d. The critical combat tasks and the combat actions were combined in a "Task/Action Concept Table" (Annex D) to determine the critical tasks which must be performed for each combat action. Since the review covers all categories of Infantry antitank weapons, a method was devised to divide these weapons into four separate classifications in order to examine more carefully each weapon system configuration. The four classifications (light antitank weapons, medium antitank weapons, ground-mounted heavy antitank weapons, and vehicle-mounted heavy antitank weapons) made it possible to consider each classification independently of the other three.

e. Consideration of the critical combat tasks which must be performed in support of the 24 combat actions revealed the following facts:

(1) All of the critical combat tasks must be performed in support of the 24 combat actions.

grouped into representative combat actions which, in their reduced form, continued to represent all the characteristics of the original 24 combat actions. On the basis of this reduction the number of combat actions was reduced from 24 to 7 representative combat actions.

f. The categories of effectiveness needed to actually discriminate between competing weapons systems were derived mainly from a detailed study of the pertinent QMR's. In addition, extensive use was made of any information gained from similar type testing, interviews with experienced test officers, and other studies in the weapon methodology field. The resulting categories of effectiveness (such as accuracy, responsiveness, reliability, and sustainability) were used as the basis for organizing the various measures of effectiveness (MOE) (Annex F). These MOE are the measurable parameters used to measure effectively, and thereby evaluate properly, small differences between competing weapons systems. The MOE are discussed by category of effectiveness in Annex F. Each MOE is considered separately in order to show its individual importance and reason for selection.

g. The MOE and the representative combat actions are both necessary to insure that competing weapons systems are examined and tested in as much detail as possible. The representative combat actions should be used to provide the nucleus for a test scenario. Proper testing should provide for all 7 representative combat actions to be

(2) Further consideration of the Infantry combat actions is not materially useful for the purpose of determining measurements which will, by themselves, permit discriminations to be made between candidate antitank weapons systems. Detailed analysis of the 24 combat actions was made in an attempt to reduce the number of combat actions for realistic testing within time limitations (see Annex E). As an analysis tool the combat actions were divided into two distinct subgroups: static operations and mobile operations. The rationale used in the selection of these two particular subgroups is based upon one major factor: the primary difference between critical combat tasks performed in support of the various combat actions is the degree of mobility of the individual/crew weapon combination at the moment of engagement. In a surprise engagement the actions of the crew in a prepared position would differ from those of a crew maneuvering in a tactical situation. The term "static operations" as used in this review implies that the crew/ weapon combination is in a static, prepared position at the time of engagement. The term "mobile operations" implies that the crew/ weapon combination is either moving or preparing to move at the time of engagement. The further reduction of combat actions was performed by combining the combat actions within the two groups on the basis of the critical combat tasks performed and the similarity of the combat actions themselves. The combat actions were then

grouped into representative combat actions which, in their reduced form, continued to represent all the characteristics of the original 24 combat actions. On the basis of this reduction the number of combat actions was reduced from 24 to 7 representative combat actions.

f. The categories of effectiveness needed to actually discriminate between competing weapons systems were derived mainly from a detailed study of the pertinent QMR's. In addition, extensive use was made of any information gained from similar type testing, interviews with experienced test officers, and other studies in the weapon methodology field. The resulting categories of effectiveness (such as accuracy, responsiveness, reliability, and sustainability) were used as the basis for organizing the various measures of effectiveness (MOE) (Annex F). These MOE are the measurable parameters used to measure effectively, and thereby evaluate properly, small differences between competing weapons systems. The MOE are discussed by category of effectiveness in Annex F. Each MOE is considered separately in order to show its individual importance and reason for selection.

g. The MOE and the representative combat actions are both necessary to insure that competing weapons systems are examined and tested in as much detail as possible. The representative combat actions should be used to provide the nucleus for a test scenario. Proper testing should provide for all 7 representative combat actions to be

used in order to test the weapons system under every normally conceivable combat situation. The MOE and their relationship to the representative combat actions are shown in Annex G. This annex reveals that the majority of the MOE can be gathered for each representative combat action. The MOE which cannot actually be considered under any representative combat action classification is that MOE which deals with crew training requirements. This training MOE is felt to be a very valuable discriminator in weapons testing and should be obtained under other than combat conditions. The importance of this MOE is clearly demonstrated when considering the crew training requirements for the ENTAC missile system versus the TOW system.

h. For the purpose of this review an antitank range was designed to demonstrate the physical requirements necessary to test antitank weapons in conjunction with 6 of the 7 representative combat actions developed in this review (combat in cities was omitted). The proposed range meets all the requirements imposed by the latest QMR's relating to antitank weapon performance requirements.

5. CONCLUSIONS.

a. The MOE discussed in this review are valid discriminators between competing antitank systems.

b. An antitank weapons test facility should provide realistic combat-type situations wherein measurements are taken in real time

through instrumentation and do not require interruption of testing.

c. The study of the combat actions enabled the identification of representative combat actions necessary to evaluate adequately the MOE in a combat environment. The reduction of the combat actions provides the test officer with a firm foundation upon which to organize and to conduct a complete and comprehensive weapons test.

6. RECOMMENDATION.

a. The MOE be accepted for use in future USAIB tests.

b. The methodology and conclusions of this review be submitted to the Litton Project Director for use in the Antitank phase of the Infantry Weapons Test Methodology Study.

LIST OF ANNEXES AND APPENDICES

ANNEX A

DISCUSSION OF ANTITANK WEAPON EMPLOYMENT

1. Increasing emphasis is being placed on the development of armored and mechanized units. The Infantryman must be prepared to operate on a battlefield dominated by armored formations. (FM 23-3, chapter 1, Section I.) In order to operate effectively he must have a relatively lightweight, man- or vehicle-portable, antitank weapons system.

2. Antitank weapons fall into three categories: light, medium, and heavy. For the most part the weapons are direct fire or line-of-sight systems. Only recently have antitank projectiles been made controllable in flight (such as the wire-guided systems).

3. The employment of antitank weapons is somewhat varied depending upon the size of the weapon and the tactical situation. However, there are certain overriding principles which govern the successful use of organic and attached antitank weapons for small units (squad, platoon, and company). These units will habitually have certain combinations of antitank weapons to employ. Regardless of the number and types of antitank weapons a unit has, it should strive for the following:

a. Antitank weapon positions which provide good fields of fire out to the maximum range of the weapon system.

b. Antitank weapons positions which are mutually supporting.

c. Antitank weapon positions which provide all-around antitank defense in depth.

d. Selection of alternate and supplementary positions which allow weapon crews to displace frequently and rapidly without losing effectiveness.

e. Local security for antitank crews which is integrated with other elements of the unit.

4. When engaging armored formations, the unit must attempt to separate the tanks from the accompanying Infantry by using artillery and small arms fire. If tanks are accompanied by armored personnel carriers, antitank weapons should concentrate on the tanks initially, using the principle of engaging the most dangerous target first. Unit leaders, through fire control and fire discipline, must insure that weapon crews distribute their fires in sector while maintaining antitank fires throughout the unit zone.

5. When individuals or small units are forced to engage tanks, a maximum effort should be made to isolate and to engage the tanks separately. Ideally, engagement should be made where tanks are most channelized and where freedom of movement is limited.

6. Antitank weapons are normally employed from a stationary position. This may be a carefully prepared position or it can be a position chosen at random, as might occur in a chance engagement. Since antitank weapons are primarily line-of-sight-type systems,

it would appear that the only major differences in method of employment between types of engagements would be attributable to weapon mobility (preparing the weapon for transport, transporting, and dismounting to prepare the weapon for firing).

ANNEX B

COMBAT ACTIONS CONSIDERED

1. The combat actions list was prepared after researching all pertinent doctrinal and training literature (Annex I). A detailed study of antitank weapon employment revealed that the combat actions "tank-hunter-killer operations" and "fire and maneuver" were two distinct areas which warranted consideration and should be included in the antitank methodology review.

2. This review deals with a wide variety of weapons (light, medium, and heavy antitank weapons) having varying capabilities. The combat actions considered do not all apply to each weapon system (for instance, the LAW would rarely be used in a combat outpost). The combat actions listed are designed to be all-inclusive and to cover every antitank weapon employment under all normally conceivable conditions:

1. Combat Outpost
2. Delaying Action
3. Roadblocks
4. Collapsing Defense in Withdrawal from LZ
5. Area or Position Security
6. Hasty Defense
7. Deliberate Defense

8. Counterattack

9. Tank-Hunter Operations

10. Frontal Assault

11. Fire and Maneuver

12. Fire and Movement

13. Consolidation

14. Exploitation

15. Breaching Operations

16. River Crossing

17. Aerial Assault

18. Ambush

19. Advance to Contact

20. Security of Moving Column

21. Search and Clear

22. Combat Patrol

23. Counterambush

24. Combat in Cities

ANNEX C

CRITICAL COMBAT TASKS

Each critical combat task is considered relative to each category of antitank weapons (light, medium, and heavy). The ranges mentioned (such as short, medium, and long) are relative to the weapon being tested and will take into consideration the weapon's minimum arming distance and maximum effective range (for instance, one antitank's minimum arming distance might be another's maximum range).

1. Long range aimed fire on selected targets.
2. Medium to short range fire--supported firing position.
3. Medium to short range fire--unsupported firing position.
4. Medium to short range fire--rapid displacement.
5. Maximum aimed fire--minimum exposure to enemy fire.
6. Rapid movement--rapid reload.
7. Rapid reaction to suitable targets.
8. Deliberate methodical movement with detailed observation.
9. Anticipated short and/or medium range enemy contact.
10. Clear fields of fire.
11. Prepare and camouflage positions.
12. Put in and/or utilize existing barriers.
13. Conduct recon of withdrawal and occupation routes.

ANNEX D
TASK/ACTION CONCEPT TABLE

TASKS \ ACTIONS	COMBAT OUTPOST	DELAYING ACTION	ROADBLOCKS	COLLAPSING DEF. WITHDRAWAL (LZ)	AREA/POSITION SECURITY	HASTY DEFENSE	DELIBERATE DEFENSE	COUNTERATTACK	TANK HUNTER KILLER OPERATIONS	FRONTAL ASSAULT	FIRE AND MANEUVER	FIRE AND MOVEMENT	REORGANIZATION AND CONSOLIDATION	EXPLOITATION	BREACHING OPNS	RIVER CROSSING	AERIAL ASSAULT	AMBUSH	ADVANCE TO CONTACT	SECURITY OF A MOVING COLUMN	SEARCH AND CLEAR	COMBAT PATROL	COUNTERAMBUSH	COMBAT IN CITIES
LONG RANGE AIMED FIRE ON SELECTED TARGETS	2 4	1 2 4		1 2	1 2	1 3 4	1 2 3 4	1 2	4	1 2 4	3 4	1 2	1 2 3 4	4	1 2 3 4	1 2	1 2	1	1 2 4	2 4	1	1 2	1	1 2
MEDIUM TO SHORT RANGE FIRE---SUPPORTED FIRING POS.	2 4	2 4	1 2 3 4				1 2 3 4	4	4	2 4	3 4		1 2 4	4	3 4	4	4	1 2 4	4	4				2 3
MEDIUM TO SHORT RANGE FIRE---UNSUPPORTED FIRING POS.	2 4			1 2	1 2	1 2 3 4		1 2	1 2	1 2	4	1 2	1 2		1 2	1 2	1 2 3		1 2	2	1 2	1 2	1	1 2
MEDIUM TO CLOSE RANGE AIMED FIRE/RAPID DISPLACEMENT	2 4	2 4		1 2		2 4	2 4		1 2 4	1 2 4	4	1 2		4	1 2	1 2 4	1 2	1 2 4	1 2 4	2 4	1 2	1 2	1	1 2 3
MAXIMUM AIMED FIRE---MINIMUM EXPOSURE TO ENEMY FIRE	2 4	1 2 4	1 2 3 4		1 2	1 2 3 4	1 2 3 4	1 2 4	1 2 4	2 4	4	2			2 3 4	2 4	2 3 4	1 2 4				1 2		1 2 3
RAPID MOVEMENT---RAPID RELOAD	2 4	2 4	1 2 3 4	1 2				1 2	1 2 4	1 2 4	4	1 2		4	1 2	2	1 2	1 2 4	1 2 4	2 4	1 2	1 2	1	1 2
RAPID REACTION TO SUITABLE TARGETS	2 4	1 2 4	1 2 3 4	1 2	1 2	1 2 3 4	1 2 3 4	1 2 3 4	1 2 4	1 2 4	4	1 2	1 2 4	4	1 2 3 4	1 2 4	1 2 3 4		4	2 4	1 2		1	1 2 3
DELIBERATE METHODICAL MOVEMENT WITH DETAILED OBS.		1 2 4						1 2 4	1 2 4	1 2 4	4								4	2 4	1 2			1 2 3
ANTICIPATED SHORT AND/OR MEDIUM RANGE ENEMY CONTACT	4	1 2 4	1 2 3 4	1 2	1 2	1 2 3 4	1 2 3 4	1 2 4	1 2 4	1 2 4	4	1 2	1 2		1 2 3 4	1 2 4	1 2 3 4	1 2 4	1 2 4	2 4	1 2	1 2		1 2 3
CLEAR FIELDS OF FIRE	2 4	1 2 4	1 2 3 4			1 2 3 4	1 2 3 4				3 4		1 2 3 4		3 4	2 4		1 2 4						
PREPARE AND CAMOUFLAGE POSITIONS	2 4	1 2 4	1 2 3 4				1 2 3 4				3 4		1 2 3 4		3 4	2 4		1 2 4						
PUT IN AND UTILIZE EXISTING BARRIERS		1 2 4	1 2 3 4				1 2 3 4		1 2 4									1 2 4						
CONDUCT RECON OF WITHDRAWAL AND OCCUPATION ROUTES	2 4	1 2 4	1 2 3 4	2		4	4		2 4									1 2 4						1 2 3

1. Light Antitank Weapons. (M-72) Law

2. Medium Antitank Weapons. (M-67) 90mm

3. Heavy Antitank Weapons. (M-40A1) 106mm and TOW GROUND MOUNTED

4. " " VEHICLE MOUNTED

ANNEX E

REDUCTION OF COMBAT ACTIONS

1. The primary purpose of the task/action concept table in Annex D is to provide a means of reducing the number of combat actions by combining those actions which show similar characteristics. Detailed study of the task/action concept table (in which 24 combat actions are compared and analyzed against 13 critical combat tasks) with primary emphasis placed on the actions of the individual/crew weapon combination, revealed that certain critical combat tasks are common to one or more combat actions. For the purpose of analysis the combat actions were divided into two distinct groups, mobile operations and static operations. This grouping into two categories allows further reduction in combat actions as shown in the analysis which follows.

2. The following discussion and analysis briefly describes each combat action and shows the basis of similarity of critical combat tasks performed. The combat actions can be grouped into a smaller number of representative combat actions each of which displays similar characteristics (in this case, measurable characteristics) of its subelements. This reduction allows a more complete and comprehensive study to be made of the representative combat actions and provides a more manageable set of parameters for use in the methodology evaluation.

a. Static operations are:

Deliberate Defense

Fire and Maneuver

Hasty Defense

Area or Position Security

Reorganization and Consolidation

Ambush

Combat Outpost

Roadblocks

(1) Deliberate Defense. The combat action, deliberate defense, is a well-planned relatively permanent defensive posture. It is characterized by thorough position preparation using every means available to defend. Reference to the task/action concept table shows that the majority of the critical combat tasks considered are performed in the deliberate defense. For this reason this combat action will be considered as a representative action which displays all the characteristics of other combat actions to be discussed later in this study.

(2) Hasty Defense. The hasty defense is an example of a defense in which little time has been allowed for position preparation and planning. Normally the hasty defense is used for a relatively short period of time (after which it either evolves into a deliberate defense or becomes an offensive or retrograde operation). The hasty

defense is a representative combat action displaying many characteristics of other combat actions.

(3) Combat Outpost. The combat outpost is a security element which denies the enemy close ground observation of the battle area and provides early warning of his advance. The combat outpost generally engages the enemy with long-range fires and avoids decisive engagement. Antitank weapons are normally positioned for mutual support to engage enemy armor at maximum range. By virtue of the critical combat tasks performed, the combat action, combat outpost, is grouped under the title, retrograde operations. This action is characterized by medium-to-long-range fires and rapid withdrawal without decisive engagement. The combat action, delaying action, falls under the category of mobile operations, and will be discussed at length later on in this study.

(4) Area or Position Security. This combat action deals with the security of a small area (such as the site of a downed helicopter or the area around a water point). In this instance it is assumed that the security element will only be in position for a relatively short period of time and will not fortify itself to the extent that it might in a more permanent situation. The critical combat tasks performed are similar to those performed during the hasty defense and can all be measured under the heading of hasty defense.

(5) Fire and Maneuver. This combat action considers only the actions of the base of fire elements and not the maneuver element

(to be discussed later in the mobile operations section under the heading of Fire and Movement). The base of fire element is primarily responsible for providing fire support for the maneuver element. Normally the base of fire element is in a static position for a fixed period of time and is characterized by aimed fire from a stationary position. Reference to the task/action concept table shows that all measurements required for fire and maneuver are included in the combat action, deliberate defense. For this reason the combat action, fire and maneuver, is combined as being a subelement of the representative combat action, deliberate defense.

(6) Roadblock. The combat action, roadblock, is used to prevent or hinder enemy movement beyond a point or area along a road or other route of advance. The planning of a roadblock is quite similar to that used in a deliberate defense. Reference to the task/action concept table shows that all the combat tasks performed in a roadblock operation are common to the deliberate defense. Based upon this fact the roadblock is combined as a subelement of the representative combat action, deliberate defense.

(7) Reorganization and Consolidation. Reorganization and consolidation pertain to actions taken to organize and strengthen a newly gained objective. Initially, a hasty defensive posture is assumed to ward off possible counterattacks. Consideration of the critical combat tasks performed during the consolidation indicates that this

combat action is characterized by minimum position preparation time under threat of imminent enemy attack and medium-to-short-range aimed fire. Since the tasks are similar to those performed in the hasty defense, it will be evaluated under that heading.

(8) Ambush. The combat action, ambush, deals with relatively close range fires from a mobile force. The individual/crew weapon actions are included in the combat action, tank-hunter killer operations, as well as in the hasty defense. The only critical combat task not covered in the combat action, hasty defense, is the task involving "deliberate methodical movement with detailed observation." This task is covered, however, in the combat action, tank-hunter killer operations. The combat action, ambush, is included as a sub-element of both hasty defense and tank-hunter killer operations.

(9) Discussion and analysis of the combat actions in the static operations category reduces the number of combat actions within the category from eight to two. The two representative combat actions remaining are the deliberate defense and the hasty defense.

b. Mobile operations are:

Fire and Movement

Tank-Hunter Killer Operations

Advance to Contact

Combat in Cities

Frontal Assault

Exploitation

River Crossing

Aerial Assault

Search and Clear

Combat Patrol

Counterattack

Counterambush

Security of a Moving Column

Breaching Operations

Collapsing Defense in Withdrawal from LZ

Delaying Action

(1) Fire and Movement. Fire and movement begins when the maneuver element meets effective enemy opposition and can no longer advance under cover of supporting fires without taking unacceptable losses. Fire and movement within the maneuver element is characterized by the action of individuals, fire teams, and squads in the assault of an objective. Maximum aimed firepower must be used to cover the advancing elements. The combat action, fire and movement, is considered as a representative combat action.

(2) Tank-Hunter Killer Operations. This combat action is characterized by small teams trained to destroy, disorganize, and delay

armored formations. Normally the teams are relatively mobile and engage their targets from close range. Since this combat action deals with special operations it is considered by itself as a representative combat action.

(3) Advance to Contact. Advance to contact is an offensive action designed to gain and maintain contact with the enemy. Consideration of this combat action indicates that it is representative of other combat actions which will be included under the title, advance to contact, as subelements.

(4) Combat in Cities. The combat action, combat in cities, is characterized by restricted observation and fields of fire as well as excellent concealment and cover for both the attacker and the defender. Movement is difficult by vehicle since streets and alleys constitute ready-made fire lanes and killing zones. Direct fire weapons must be well forward in order to be effectively employed. By virtue of its wide spectrum of critical combat tasks the combat action, combat in cities, must be designated as a presentative action.

(5) Frontal Assault. The frontal assault is normally the final assault on the objective and is characterized by a high volume of fire both aimed and suppressive in nature. Reference to the task/action concept table indicates that all critical combat tasks performed during

this combat action are also performed during the combat action, fire and movement. For this reason the combat action, frontal assault, is included as a subelement of fire and movement.

(6) Exploitation. Exploitation is an offensive operation which may follow a successful penetration or envelopment. It is characterized by relatively rapid movement and mobility with the primary emphasis being placed upon keeping the enemy disorganized and in a state of retreat. Only a limited number of critical combat tasks are performed during this combat action and for this reason it will be included as a subelement of the representative combat action, fire and movement. This grouping will allow all the measurable parameters of exploitation to be evaluated.

(7) River Crossing and Aerial Assault. Both of these combat actions deal with forms of mobility (assault boat, helicopter, etc.) followed by the combat actions of fire and movement, advance to contact, and hasty defense, all of which are discussed as separate combat actions. Since this is a study of antitank weapons, the role of the assault boat or combat helicopter in the operation will be considered to be primarily one of supplying mobility to the ground troops.

(8) Search and Clear. The combat action, search and clear, is a special operation used as an effective measure to combat guerrilla

forces. It is characterized by alert movement with rapid reaction to enemy fire, medium to short range enemy contact, and aggressive action to gain and maintain enemy contact. The critical combat tasks performed during this combat action are also included in the representative combat action, advance to contact, and allow the search and clear operation to be considered and evaluated as a subelement of this representative combat action.

(9) Combat Patrol. Combat patrols are heavily armed detachments sent out to kill or capture the enemy or to destroy his equipment, materiel, or installations. They are characterized by alert movement with rapid reaction to enemy fire, medium to short-range enemy contact, and aggressive, violent action to destroy the enemy. Mobility and firepower are two necessary ingredients of this combat action. The critical combat tasks performed during the combat patrol are also considered during the representative combat action, advance to contact. Reference to the task/action concept table indicates that this combat action can be completely evaluated as a subelement of advance to contact.

(10) Counterattack. A counterattack is a limited-objective attack designed to destroy or eject the enemy from an area of penetration and to regain lost portions of the battle area. This combat action deals with a total group reaction and is consequently difficult to measure on an individual basis. The reaction of the group is the result of considerable training and teamwork involving

the same individual/crew actions found in fire and movement. This combat action can be properly evaluated as a subelement of the representative combat action, fire and movement.

(11) Counterambush. The counterambush, much like the counterattack, deals with a total group reaction and is consequently difficult to measure on an individual basis. The critical combat tasks performed can all be evaluated under the representative combat action, fire and movement.

(12) Security of a Moving Column. This combat action includes alert movement with rapid reaction to enemy fire, and medium-to-short-range enemy contact. Reference to the task/action concept indicates that all the tasks considered are also covered under the representative combat action, advance to contact.

(13) Breaching Operations. The role of the antitank weapon in this combat action is to neutralize the fires of a bunker under attack, enemy forces in open emplacements around the bunker, and locations suspected of containing enemy who can hinder the advance of a maneuvering element. All the critical combat tasks performed in this combat action can be evaluated under the representative combat action, fire and movement.

(14) Collapsing Defense in Withdrawal from an LZ. This combat action is a special operation brought about by the introduction of the helicopter as a primary source of mobility in combat. It deals primarily with a progressively decreasing perimeter defense designed

to protect the operations on the LZ itself. The critical combat tasks performed are varied and most closely resemble the tasks required in retrograde operations. The task/action concept table shows that all the critical combat tasks can be properly evaluated under the representative combat action, delaying action.

(15) The 24 combat actions initially considered have now been reduced to 7. Each critical combat task considered in the 24 combat actions is also considered in the 7 representative combat actions.

COMBAT ACTIONS	REPRESENTATIVE COMBAT ACTIONS
STATIC OPERATIONS	
Deliberate Defense	DELIBERATE DEFENSE
Fire and Maneuver	
Roadblocks	
Hasty Defense	HASTY DEFENSE
Area or Position Security	
Reorganization and Consolidation	
Ambush	
Combat Outpost	
MOBILE OPERATIONS	
Delaying Action	DELAYING ACTION
Collapsing Defense in Withdrawal from LZ	
Fire and Movement	FIRE AND MOVEMENT
Exploitation	
Breaching Operations	
Counterattack	
Counterambush	
Frontal Assault	
Tank-Hunter Killer Operations	TANK-HUNTER KILLER OPERATIONS
Combat in Cities	COMBAT IN CITIES
Advance to Contact	ADVANCE TO CONTACT
Security of a Moving Column	
Search and Clear	
Combat Patrol	

River Crossing
Aerial Assault

(Form of mobility followed by: Frontal Assault, Fire and Movement, Advance to Contact, or Hasty Defense.)

ANNEX F

DISCUSSION OF MEASURES OF EFFECTIVENESS

1. GENERAL. Consideration of the categories of effectiveness, such as accuracy, responsiveness, reliability, sustainability, etc., revealed that these categories must be defined in terms of measurable parameters which meaningfully relate to a combat situation. Once defined, these parameters were further studied and developed into measures of effectiveness (MOE) in order to measure effectively and then to evaluate properly small differences between competing weapons systems. These MOE evolved in four ways:

a. Measures that must be collected in order to compile other data, such as number of hits. By itself, this measurement has little meaning, but when combined with number of rounds fired, a hit probability can be obtained.

b. Measures that stand alone, such as time to first round. This measurement of effectiveness stands alone as a measure of the amount of time it takes to fire a round once a target is identified.

c. Measures that are combinations of two or more measures. For example, engagement hit probability is a consideration:

$$\frac{\text{Number of Target Hits}}{\text{Number of Rounds fired}} = \text{Engagement Hit Probability}$$

d. Measures specifically designed to evaluate special situations such as the probability of a first-round hit with an antitank weapon in a tank-hunter-killer operation.

$$\frac{\text{Number of First Round Target Hits}}{\text{Number of Rounds fired}} = \text{Probability of First Round Hit}$$

The measures of effectiveness are discussed below by category of effectiveness.

2. ACCURACY. There are five measures considered in the category of accuracy.

a. Number of hits. This information can be obtained in two ways. The test officer may physically go downrange and count the number of holes in the target, or he may rely on collecting the data electronically. The electronic collection of data is preferable since it would allow the exercise to be conducted in a continuous manner with no halts for data collection. Realism would thus be enhanced and the "combat atmosphere" retained. The information obtained is used to compile other data, e.g., when combined with number of rounds fired, hit probability may be derived.

b. Distribution of near misses. The high cost of ammunition for antitank weapons makes this measurement a particularly desirable one. An accurate method of measuring the location of near misses would be invaluable since it might indicate that the weapons system

is, in fact, accurate but that the sight is misaligned or even more important, improperly designed. This added data would greatly assist the test officer in his analysis of weapon performance and would reduce the risk of rejecting an acceptable weapons system.

c. Engagement/hit probability.

(1) This MOE is a hybrid measure not directly observed but computed from the number of hits observed divided by the number of rounds fired under a given set of conditions. Hit probabilities only reflect combat performance to the extent that the test environment reflects combat environment. Hit probabilities obtained on a known distance target range may indicate large differences between competing weapons systems but do not necessarily predict performance that could be expected under combat conditions.

(2) To be a meaningful measure, much care must be taken in test design and conduct so that observed results can be applied to actual combat.

(3) Several types of hit probabilities should be measured under the simulated combat conditions of the test facilities. These would include probability of first and subsequent round hits. Hit probabilities are used to compare weapon performance on the test facilities as a function of range, angle of fire, type of target, weapon, learning, training or any combination of these variables. To the extent that test conditions relate to combat, this measure is an

evaluation of the total performance of the individual/crew weapon system in combat. The MOE can be referred to as a gross measure, not relating to a specific action such as sight alignment, but to the sum of the actions of the individual/crew as they use the weapon.

(4) In general, engagement hit probabilities will indicate weapon differences. However, other measures are necessary to isolate discrete causes of weapon differences.

d. Probability of First Round Hit. This measure is particularly important with antitank weapons since there is rarely a chance to fire a second round at an armored target. In antitank warfare a great deal of importance is placed upon "first round kill" capability. It is conceivable that this measure could be a key factor in the selection of competing weapons systems. In the last few years a great deal of development has gone into trying to develop antitank rounds which could be guided in flight to increase further the probability of a first round hit. This probability is easily computed provided other physical measurements have been taken.

e. Rounds Fired. The number of rounds fired is a basic measure required in the determination of key derived measures, e.g., hit probability.

$$\frac{\text{Number of First Round Target Hits}}{\text{Number of Rounds Fired}} = \text{Probability of First Round Hit}$$

3. RESPONSIVENESS. This is basically a time-related measurement which gives an indication of how rapidly a weapon may be made to perform

its assigned function. Under extreme conditions a man might be required to operate a crew-served weapon by himself. Responsiveness in this case would be a measure of how easily the weapon can be controlled and made to operate properly. The eight measures of effectiveness considered in the category of responsiveness are:

a. Time to First Round. This MOE provides data on the length of time it takes the crew (or individual firer, depending upon the weapon) from target identification to (1) assume a firing position and perform the necessary crew drill, (2) acquire the target in the weapon's sighting system, and (3) fire the first round. The importance of this measure varies from combat action to combat action. As in several of the combat actions, particularly those in which alert movement is required, a quick response to surprise fire or targets of opportunity is essential.

b. Time to Reload. This measurement is primarily based upon weapon and round design. Crew familiarity with the weapon system will serve to reduce this time and consequently the crews for two competing weapons systems must display equal levels of proficiency with their weapons systems. The time to reload becomes particularly important as a measurement when multiple targets are engaged by the same weapons system.

c. Time to First Hit. Ideally this measurement should be the same as that described in subparagraph a above, with the time of

flight of the projectile added. The value of this MOE is relatively high since a hit must be achieved for mission accomplishment. The more time required to achieve a first hit only serves to reduce the chances of successful mission accomplishment. Target identification time is considered constant. Therefore, MOE "time to first hit" is actually the time required to aim and achieve a a hit. In a 2-weapon comparison the weapon requiring the least amount of time and rounds between first round and first hit could gain a decided advantage.

d. Time to Prepare to Fire. This MOE provides information on some of the human engineering aspects of a weapon system. Time to prepare to fire actually measures crew drill time with reference to the weapons system being examined. Such items as poor tripod or mount construction, awkward sighting mechanisms, lack of carrying or handling brackets, and extreme system weight could be detected through the use of this MOE.

e. Time Between Rounds. This MOE is actually a combination of the time required to reload with the time needed to acquire the target in the sights and to manipulate the firing mechanism. The measurement could be used to isolate differences between competing weapon sighting and firing devices. An extremely complex and sophisticated system which requires a great deal of operator training and expertise might jeopardize its changes of acceptance through the use of this MOE.

f. Time to Shift Fires. This MOE is a combination measurement that provides data on the time required to shift fire to another target after achieving a target hit and to acquire the new target. Position change time (if required), sight manipulation time (if required), traversing and elevation mechanism time (if required), reloading, sight alignment, and firing are all incorporated into this measurement. With the antitank weapon system and its method of employment, this measurement might well include the time required to move to an alternate or supplementary firing position and consequently would involve measures of portability and maneuverability.

g. Time Between Hits. This measurement can be obtained for two different situations. The time required between hits on the same target would be one situation while the time required to shift fire and obtain a hit on a new target (shift and acquisition time) would be the other situation. This MOE can also be construed as a measure of stability of the weapon system since more time will be required to reload, realign and fire an unstable system as compared to one that needs only minor adjustment to achieve a second hit on the same target.

h. Sight Manipulation Time. This MOE provides data on the amount of time required to mount the sight on the weapon (if applicable) or to set up the sighting mechanism (if remote from the weapon) and perform all adjustments necessary to enable the weapon system to engage and destroy a target.

i. All of the above measures (under the category of responsiveness) are compiled and can be computed as separate functions of range, target type, firing angle, position of firer, and type of mount (these separate functions should be varied as much as possible during weapon testing). For example:

(1) Range: There will be a difference in time for all of the MOE in that the category of responsiveness based on range--varying from the minimum arming distance for the projectile out to the maximum effective range--will directly affect the time required to align the sights and the target.

(2) Firing angle: The firing angle may be expressed in degrees and direction such as 90° left and 45° right; in addition, vertical angles must be considered (such as 5° above or below the horizontal). Both of these angles must be taken into consideration when collecting and computing data on the MOE.

(3) Target type: The various types and sizes of targets found on the battlefield (tanks, bunkers, large groups of men) and their ability to move at varying speeds (man and vehicles) must be taken into consideration when collecting and computing data on the MOE.

(4) Position of crew/weapon: This MOE considers such factors as: supported or unsupported firing positions, positions offering clear fields of fire as opposed to those which offer many obstacles and terrain which permits stable positioning of the weapon as opposed

to rocky or muddy terrain which might cause difficulty in mounting the weapon in its proper firing configuration. All of these factors and many others within this category must be considered when computing or recording data on the MOE.

(5) Type of Mount: This would take into consideration such different mounting systems as man mounted or held, tripod or bipod mounted, and vehicle mounted. Again, as with the previous categories, consideration must be taken when collecting and computing data on the MOE.

4. SUSTAINABILITY.

a. This category of effectiveness is indicative of the life of a weapon in a combat environment with respect to the basic load of ammunition for the weapon. All measures of effectiveness (total rounds, number of rounds to first hit, number of rounds between hits, and number of rounds fired per engagement) are contributive. Sustainability, therefore, is best described as hits per pound with respect to the basic load of the weapon system. This measure will allow us to compute the number of hits per basic load (this would break down also to number of engagements per basic load if each hit were considered a kill).

b. Sustainability relates the combat effectiveness of the system to its basic load and attempts to anticipate the amount of

time or the number of engagements the system can expect to remain in a combat action. Basic loads are often augmented or changed by local directives (taking into consideration the threat posed by enemy armor). The amount of trade-off between hit probability and ammunition weight would have to be a decision based upon situation and anticipated threats. This MOE should be evaluated during testing of a new or modified antitank weapons system.

5. RELIABILITY. The two measurements of effectiveness considered in the category of reliability are:

a. Time to Clear Malfunctions. A malfunction is a failure of the weapons system to function satisfactorily. Improper operation of the weapon by a crew member is not considered a malfunction. The importance of this MOE is obvious since a malfunction effectively neutralizes the weapon's usfulness.

b. Number of Rounds Between Malfunctions. This MOE is an indication of the true reliability of the weapons system. The MOE must be sequentially counted by round fired, from the initial round fired throughout completion of all firing exercises. The data obtained are necessary to compute the probability that a round will be fired when the trigger is pulled.

6. PORTABILITY AND COMPATIBILITY.

a. The measurements of effectiveness considered in the category of portability and compatibility vary from combat action to combat action, are difficult to measure accurately, and cannot generally be measured with instrumentation. The entire category is considered to be a human factors judgment area and will be considered in each combat action to detect anything about the weapon which may hinder the individual/crew weapon performance. As an example, the ease of handling a weapon system might be excellent while the weapon is cold, but once it is heated by sustained fire the ease of handling might suddenly become extremely poor.

b. Performance measures include but are not limited to the following:

(1) Ease of handling (hot/cold). This is a comparison measurement between ease of handling before the weapon has been fired (or before it has been fired sufficiently to significantly raise weapon temperature) and after the weapon has been heated by sustained fire.

(2) Movement time. This measurement evaluates speed of movement with the weapon in various combat situations.

(3) Preparation of position and emplacement of barriers. This measurement evaluates speed of position preparation and barrier emplacement. Reaction time of the individual/crew/weapon combination

to enemy activity during the performance of these combat tasks is carefully analyzed in order to detect differences between competing weapons systems.

(4) Compatibility with ancillary equipment. This is a measurement of how well the weapons system and its various components complement each other.

(5) Maneuverability when changing positions and/or crossing obstacles. This measurement evaluates the speed and ease in which the individual/crew/weapon combination is able to change position or negotiate a given obstacle. The data obtained are useful in a 2-weapon comparison.

(6) Time to dismount/remount weapon from/on vehicle mount. This measurement evaluates the speed and ease with which the individual/crew can dismount or remount a vehicle-mounted weapons system. The data compiled can be used for a 2-weapon comparison.

(7) Crew training requirements. The time and efforts required to train a crew or individual on a specific weapons system are factors which must be considered. This measurement may be used in the comparison of two or more weapons systems.

(8) Ability to engage a moving target. This measurement is an indication of the weapon's traversing and elevating capability with respect to the individual/crew operating the system.

(9) Troop safety area required. Different weapons systems require a variety of troop safety consideration with respect to back

blast or muzzle blast. A measurement of the safety area required can be used in a 2-weapon comparison.

7. SIGNATURE EFFECTS. The five measurements considered in the category of signature effects are:

a. Sound level recording (blast). This signature effect will be measured and evaluated in two parameters: (1) to determine if there is any danger to the firer's and adjacent firers' ears; and (2) to determine if the sound of the weapon will readily identify its location on the battlefield.

b. Obscuration (smoke and haze). This signature effect will be measured to: (1) to determine if the muzzle blast kicked dirt and dust into the air in sufficient amounts to interfere with the sighting and aiming process; (2) to determine position disclosing effects.

c. Visual light emission (flash). This signature effect will be measured. The muzzle flash is the most noticeable signature effect and as such tends to disclose the firer's position. Flash can be measured in such terms as size, duration, and intensity during day and night conditions.

d. Backblast. Any identifiable backblast features such as smoke, haze, and blow down which serve to disclose the weapon's position will be measured.

e. Infrared signature. This is a measure of how easily the weapon can be detected by infrared devices. This measurement

draws its importance from the fact that infrared devices are becoming more and more common on the battlefield. The data obtained by measuring acquisition ease are useful in a 2-weapon comparison.

8. DURABILITY. There are two measurements considered in this category.

a. Ability to operate properly after extended movement and/or handling. This measurement is useful in determining the relative durability of two or more weapons systems. It is assumed that the extended movement and/or handling will be done in a combat-like environment and will subject the weapon to stresses normally experienced in such an environment.

b. Amount of breakage as a function of operational environment (relative to a standard or competing system). This measurement, much like the one above, is designed to detect durability failures and to apply this measurement in a 2-weapon comparison. Breakage which renders the weapon inoperative should be noted and distinguished from breakage which does not affect weapon operation.

9. STABILITY.

a. Mount stability. The stability of the gun platform is a vital consideration. Failure during firing could result in mission failure as well as increase the risks taken by the individual/crew operating the weapons system.

b. Stability after changing positions. The tests of bipod, tripod, and vehicle-mount stability can be performed in conjunction with

other firing exercises. The mounts should be tested on various types of terrain: muddy, wet, solid, high grass, dry grass, sand bags, hills, etc., as well as in the various combat actions. The mounts will be observed in each varying situation to detect anything about the weapon which may hinder the individual/crew/weapon combination in the performance of its mission.

APPENDIX I TO ANNEX F

MEASURES OF EFFECTIVENESS

ACCURACY

Number of hits

Distribution of near misses

Engagement/hit probability

Probability of first round hit

Rounds fired

RESPONSIVENESS

Time to first round

Time to reload

Time to first hit

Time to prepare to fire

Time between rounds

Time to shift fires

Time between hits

Sight manipulation time

SUSTAINABILITY

Hits per pound with respect to basic load

RELIABILITY

Time to clear malfunctions

Number of rounds between malfunctions

PORTABILITY AND COMPATIBILITY

Ease of handling (hot/cold)

Movement time

Preparation of position and emplacement of barriers

Compatibility with ancillary equipment

Maneuverability when changing positions and/or crossing obstacles

Time to dismount/remount weapon from/on vehicle mount

Crew training requirements

Ability to engage a moving target

Troop safety area required

SIGNATURE EFFECTS

Sound level recording (blast)

Obscuration (smoke and haze)

Visual light emission (flash)

Backblast

Infrared signature

DURABILITY

Ability to operate after extended movement and/or handling

Amount of breakage as a function of operational environment

STABILITY

Mount stability (wet/dry)

Stability after changing positions (wet/dry)

MEASURES OF EFFECTIVENESS

ANNEX G

CATEGORY	REPRESENTATIVE COMBAT ACTIONS	DELIBERATE DEFENSE	HASTY DEFENSE	RETROGRADE OPERATIONS	FIRE AND MOVEMENT	TANK HUNTER-KILLER OPERATIONS	COMBAT IN CITIES	ADVANCE TO CONTACT
ACCURACY	Number of hits	X	X	X	X	X	X	X
	Distribution of near misses	X	X	X	X	X	X	X
	Engagement/hit probability	X	X	X	X	X	X	X
	Rounds fired	X	X	X	X	X	X	X
	Probability of first round hit	X	X	X	X	X	X	X
RESPONSIVENESS	Time to first round	X	X	X	X	X	X	X
	Time to reload	X	X	X	X	X	X	X
	Time to first hit	X	X	X	X	X	X	X
	Time to prepare to fire	X	X	X	X	X	X	X
	Time between rounds	X	X	X	X	X	X	X
	Time to shift fire	X	X	X	X	X	X	X
	Time between hits	X	X	X	X	X	X	X
	Sight manipulation time	X	X	X	X	X	X	X
SUSTAINABILITY	Hits per pound with respect to basic load	X	X	X	X	X	X	X
RELIABILITY	Time to clear malfunctions	X	X	X	X	X	X	X
	Number of rounds between malfunctions	X	X	X	X	X	X	X
PORTABILITY AND COMPATIBILITY	Ease of handling (hot/cold)	X	X	X	X	X	X	X
	Movement time	X	X	X	X	X	X	X
	Preparation of position	X	X				X	
	Compatibility with ancillary equipment	X	X	X	X	X	X	X
	Maneuverability when changing positions and/or crossing obstacles	X	X	X	X	X	X	X
	Time to dismount/remount weapon from/on vehicle mount		X	X			X	
	Crew training requirements							
	Ability to engage a moving target	X	X	X	X	X	X	X
	Troop safety area required	X	X	X	X	X	X	X
SIGNATURE EFFECTS	Sound level recording (blast)	X	X	X	X	X	X	X
	Obscuration (smoke and haze)	X	X	X	X	X	X	X
	Visual light emission (flash)	X	X	X	X	X	X	X
	Back Blast	X	X	X	X	X	X	X
	IR Signature	X	X	X	X	X	X	X
DURABILITY	Ability to operate properly after extended movement and/or handling	X	X	X	X	X	X	X
	Amount of breakage as a function of operational environment	X	X	X	X	X	X	X
STABILITY	Mount stability (wet/dry)	X	X	X	X	X	X	X
	Stability after changing positions (wet/dry)	X	X	X	X	X	X	X

ANNEX H

PROPOSED ANTITANK WEAPONS RANGE

1. General. Any tests of candidate antitank weapons must be conducted on a reliable instrumented facility on which the two competing weapons can be realistically compared. This facility should provide the following:

a. Sufficient terrain to maneuver the tactical unit (weapons platoon, tank-hunter-killer team) to which the candidate weapons are normally assigned.

b. The ranges and safety fans necessary to test the maximum effective range of the candidate weapons.

c. Moving target system: track and wheel vehicles, personnel type.

d. Prepared defensive positions, position defilade firing positions, and assault firing positions.

e. Point fire targets representing tanks, APCs, and bunkers.

2. Discussion. The antitank range shown in Figure 1 of this annex does not represent any particular piece of terrain. The proposed range is merely an example of what an antitank range should look like.

a. The range is designed to test the following combat actions:

(1) Deliberate Defense.

(2) Hasty Defense.

(3) Delaying Action.

(4) Fire and Movement.

(5) Tank-Hunter-Killer Operations.

(6) Advance to Contact.

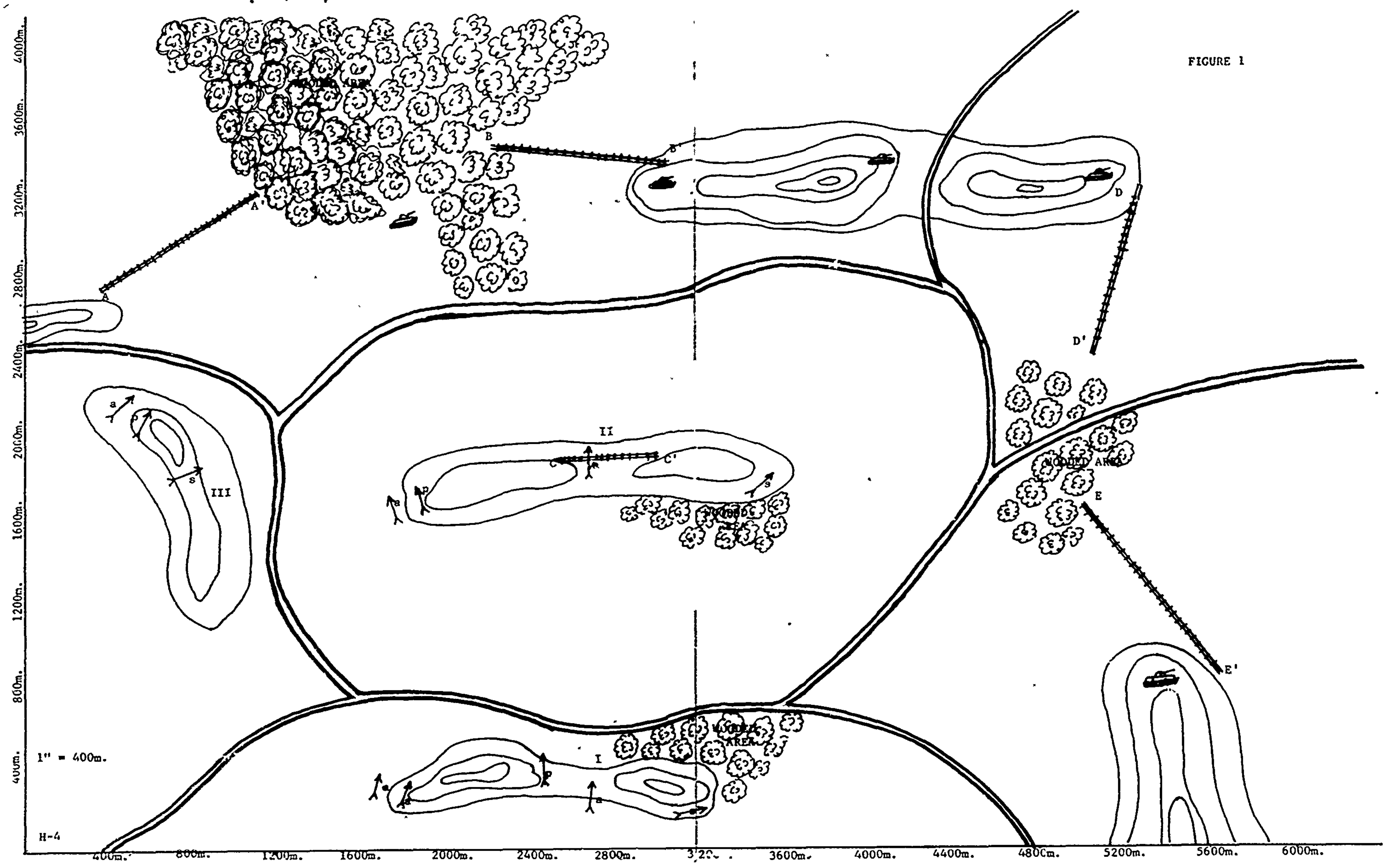
The combat actions tested on the range comprise 6 of the 7 representative combat actions selected by this study. The representative combat action "Combat in Cities" must be tested on another range due to special problems encountered in such a test.

b. A certain amount of crew training will be required upon receipt of a new weapons system prior to actual testing. This will include static firing and firing at a moving target. Range facilities for this training must be considered to be locally available and consequently will not require design consideration on the projected test range.

c. The proposed range (see Figure 1) has 5 moving targets (A-A', B-B', C-C', D-D', and E-E'), 5 stationary tank targets, and three different firing positions (I,II,III) with primary, alternate, and supplementary firing positions. All the combat actions listed under 2a can be performed on this range. Deliberate and hasty defense positions are available at firing locations I, II, and III. The ranges from firing location I satisfy the most extreme requirements of the present QMRs on heavy antitank weapons. Delaying actions can be programmed using any of the numerous woodlines and firing positions

as well as the road network for maneuvering. Fire and movement and tank-hunter-killer operations can both be demonstrated along with the advance to contact. The terrain and target locations permit a variety of test scenarios to be made.

FIGURE 1


4000m.
3600m.
3200m.
2800m.
2400m.
2000m.
1600m.
1200m.
800m.
400m.
400m.
800m.
1200m.
1600m.
2000m.
2400m.
2800m.
3600m.
4000m.
4400m.
5200m.
5600m.
6000m.
A
A'
B
D
D'
E
E'
I
II
III
C
C'
WOODED AREA
1" = 400m.

ANNEX I

REFERENCES

ARMY SUBJECT SCHEDULES

7-1	Organization, Mission, Capabilities and Characteristics of the Infantry, Mechanized Infantry and Airborne Battalions
7-2	Rifle Squad Tactical Training
7-3	Weapons Squad Tactical Training
7-4	Ground Surveillance Team and Section, Tactical Training
7-7	81-mm Mortar Squad Tactical Training
7-9	Patrolling
7-10	Land Navigation
7-11B10	Changes 1 and 2, MOS Technical Training and Refresher Training of Light Weapons Infantryman--MOS 11B10
7-11C10	Changes 1 and 2, MOS Technical Training and Refresher Training of Infantry Indirect-fire Crewman
7-11H10	Changes 1 and 2, MOS Technical Training and Refresher Training of Infantry Direct-fire Crewman
7-11H30	MOS Technical Training of Infantry Direct-fire Crewman (ENTAC Antitank Guided Missile Gunner)--MOS11H30
7-12	Antiinfiltration and Counterguerrilla Training
7-27	Heavy Mortar Platoon Tactical Training
7-30	Rifle Platoon Tactical Exercise
7-31	Weapons Platoon Tactical Exercise
7-35	Antitank Platoon Tactical Exercise
7-40	Rifle Company Tactical Exercise
7-50	Air Movement Training

7-51	Airborne Proficiency
7-53	Drop Zone Assembly
17-37	Rifle Squad, Armored Car or Reconnaissance Platoon
21-12	Survival, Evasion and Escape
21-16	Antiinfiltration and Guerrilla Warfare Training
21-19	Field Fortifications
21-20	Individual Tactical Training

ARMY TRAINING PROGRAMS

7-4	Change 1, Infantry, Airborne and Mechanized Division, HHC
7-4-1	Infantry, Airborne and Mechanized Division
7-15	Infantry, Airborne Infantry, Airmobile Infantry, Light Infantry and Mechanized Infantry Battalions and Brigades
7-16	Change 1, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions
7-16-1	Change 1, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions
7-18	Rifle Company, Infantry, Airborne, Airmobile and Light Infantry Battalions
7-18-1	Rifle Company, Infantry, Airborne, and Mechanized Infantry Battalions
7-42	HHC, Infantry, Airborne, and Mechanized Brigades
7-42-1	Change 1, HHC, Infantry, Airborne Infantry, Airmobile Infantry, and Mechanized Infantry Brigades
7-47	Rifle Company, Mechanized Infantry Battalion
7-52	HHC, Infantry Brigade, Separate
7-56	HHC, Airmobile and Light Infantry Battalions

7-58	Combat Support Company, Airmobile and Light Infantry Battalion
7-157	Infantry Long Range Patrol Company
7-167	Infantry Platoon (Scout Dog) (TOE 7-167)
7-168	Pathfinder Platoons (Sections) (Detachments)
17-18	Change 1, Air Cavalry Troop (TOE 17-78 and 17-108)

ARMY TRAINING TESTS

7-15	Infantry Battalions
7-16-1	Heavy Mortar Platoon, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions
7-16-3	Antitank Platoon, HHC, Infantry, Airborne Infantry, and Mechanized Infantry Battalions
7-18	Change 1, Rifle Company, Infantry and Light Infantry Battalions
7-35	Airborne Infantry Battalions
7-37	Rifle Company, Airborne Infantry Battalions
7-45	Mechanized Infantry Battalion
7-47	Rifle Company, Mechanized Infantry Battalion
7-55	Airmobile Infantry Battalion
7-157	Infantry Long Range Patrol Company
7-168	Pathfinder Platoon (Section) (Detachment) (TOE 1-56, 1-76, 1-101, 1-256, and 7-168)
17-78	Air Cavalry Troop of the Armored Cavalry Squadron USAARMS and Armored Cavalry Regiment
21-4	Proficiency Test for Infantry AIT
21-2	Individual Proficiency in Basic Military Subjects

FEA PROJECT

629-5	Development of Methodology for Evaluating Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers, Dunlap and Associates, May 1963

FIELD MANUALS

3-8	Change 1, Chemical Reference Handbook
5-13	The Engineer Soldier's Handbook
7-11	Change 1, Rifle Company, Infantry, Airborne and Mechanized
7-15	Change 1, Rifle Platoon and Squads, Infantry, Airborne and Mechanized
7-20	Infantry, Airborne Infantry, and Mechanized Infantry Battalions
7-30	The Infantry Brigades
17-36	Division Armored and Air Cavalry Units
21-5	Change 1, Military Training Management
21-41	Change 1, Soldiers Handbook for Defense Against Chemical Biological Operations and Nuclear Warfare
21-50	Ranger Training and Ranger Operations
21-75	Combat Training of the Individual Soldier and Patrolling
21-76	Changes 1 and 2, Survival
21-77	Evasion and Escape
21-150	Combatives
22-5	Drill and Ceremonies
22-100	Military Leadership
23-3	Techniques of Antitank Warfare
23-5	US Rifle Caliber .30, M-1

23-6	Changes 1 and 2, Antitank Guided Missile (ENTAC)
23-7	Changes 1 and 2, Carbine Caliber .30, M-1, M1A1, M2 and M3 (AFM 50-4)
23-8	Change 1, US Rifle--7.62-mm, M-14 and M14A1
23-9	Change 1, Rifle, 5.56-mm, M16A1
23-11	Change 2, 90-mm RR Rifle, M67
23-12	Technique of Fire of the Rifle Squad and Tactical Application
23-15	Browning Automatic Rifle, Caliber .30, M1918A2
23-16	Change 1, Automatic Rifle Marksmanship
23-23	Change 1, Antipersonnel Mine M18A1 and M18 (Claymore)
23-30	Changes 1-3, Grenades and Pyrotechnics
23-31	Change 1, 40-mm Grenade Launcher, M79
23-32	Change 1, 3.5-inch Rocket Launcher
23-33	Change 1, 66-mm HEAT Rocket, M72
23-35	Pistols and Revolvers (AFM 50-17)
23-41	Submachine Guns, Caliber .45, M3 and M3A1
23-55	Browning Machineguns Caliber .30, M1919A6 and M37
23-65	Changes 1 and 2, Browning Machinegun Caliber .50 HB, M2
23-67	Machinegun 7.62-mm, M60
23-71	Rifle Marksmanship
23-72	Change 1, Carbine Marksmanship Courses, TRAINFIRE I
23-82	106-mm RR M40A1
23-85	60-mm Mortar, M19
23-90	Change 1, 81-mm Mortar, M29
23-92	Changes 1-4, 4.2-inch Mortar, M30

31-10	Denial Operations and Barriers
31-16	Counterguerrilla Operations
31-18	Change 1, LRR Ranger Company
31-21	Special Forces Operations--USA Doctrine
31-23	Stability Operations, USA Doctrine
31-25	Desert Operations
31-30	Jungle Training and Operations
31-36	Night Operations
31-50	Change 1, Combat in Fortified and Built-up Areas
31-55	Border Security/Antiinfiltration Operations
31-60	River Crossing Operations
31-70	Basic Cold Weather Manual
31-71	Change 1, Northern Operations
31-72	Mountain Operations
31-73	Advisor Handbook for Stability Operations
31-75	Riverine Operations
57-1	US Army/US Air Force Doctrine for Airborne Operations (AFM 2-51)
57-35	Airmobile Operations
57-38	Pathfinder Operations

TRAINING CIRCULARS

5-31	Change 1, VC Boobytraps, Mines, and Mine Warfare Techniques
23-10	Change 1, 40-mm Grenade Launcher XM148
23-11	Starlight Scope Small Hand-held or Individual Weapons Mounted Model No 6060

23-12	Change 1. Target Detection--Crack and Thump Technique
23-13	Crew Served Weapon Night Vision Sight
23-15	Engagement of Aerial Targets with Small Arms
23-18	Night Observation Device, Medium Range (NODMR)
23-20	M16A1 Rifle Training
23-21	Familiarization Firing Course: APC M113 with Armament Kit

USATECOM PROJECTS

0-3-7700-01E Identification of Important Tasks of Combat Infantry, Nov 64

RELATED MATERIAL

Litton Systems, Inc., Mellonics Division, DA EA 18-68-C-0004, "Project Analysis, Antitank Weapons Test Range," 9 January 1970.

MTP 3-3-040, USATECOM Commodity Service Test Procedure, "Launcher, Rocket, Individual Weapon," January 1969.

MTP 5-3-057, USATECOM Commodity Service Test Procedure, "Missile, Guided, Antitank," November 1969.

APPENDIX III

PROJECT ANALYSIS
ANTITANK WEAPONS TEST METHODOLOGY

AD________________________________

CONTRACT NO DAEA 18-68-C-0004

USAIB PROJECT NO 3319

PROJECT ANALYSIS

ANTITANK WEAPONS TEST METHODOLOGY

BY

RONALD D. KLEIN

LITTON SYSTEMS, INC.
MELLONICS SYSTEMS DEVELOPMENT DIVISION

27 November 1970

UNITED STATES ARMY INFANTRY BOARD
FORT BENNING, GEORGIA 31905

FOREWARD

This project analysis has been performed under contract DAEA 18-68-C-0004 in connection with the Infantry Weapons Test Methodology Study conducted by the United States Army Infantry Board, Fort Benning, Georgia.

TABLE OF CONTENTS

ANNEXES

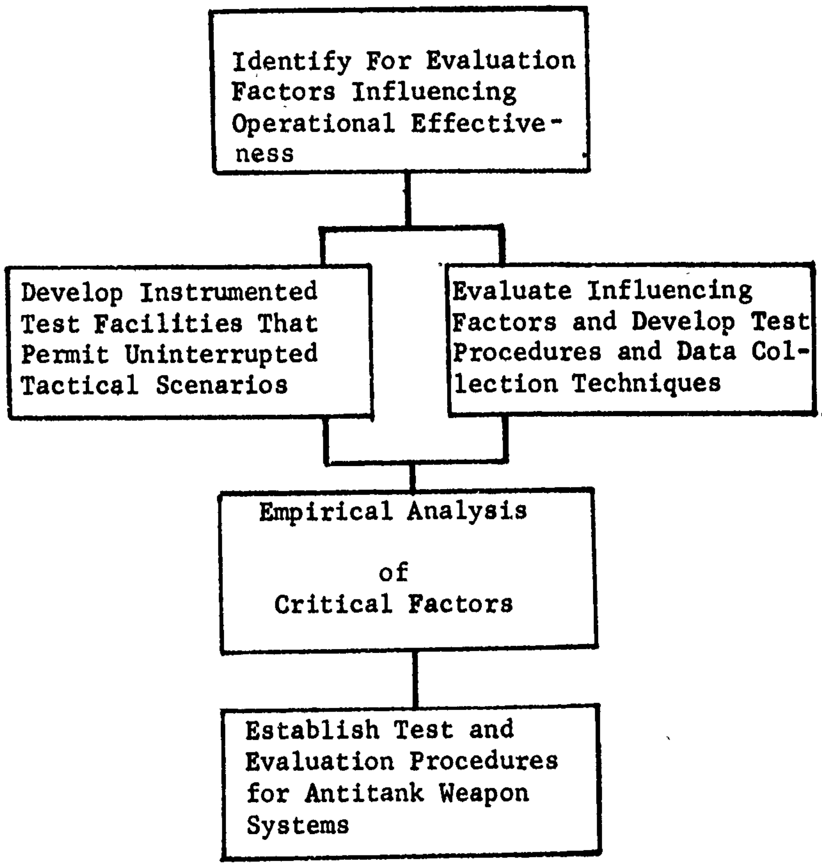
PURPOSE AND OBJECTIVES

The purpose of this analysis is to establish basic test concepts for the operational evaluation of anti-tank weapon systems. The concepts include the development of test facilities, test methods and procedures, instrumentation requirements, and data collection and processing requirements. To provide general guidelines for this study, an attempt is made to identify critical factors which should be considered as the methodology study continues. Each critical factor is discussed and recommendations for elimination or incorporation are made. If the factor is defined to be within the area of responsibility of the service test, or is expected to have significant impact on weapon system evaluation, procedures for incorporation are presented. In this manner, this project analysis systematically narrows the number of factors until the scope of the antitank methodology study is defined.

The goal of the antitank methodology study is to insure that critical factors are included in service testing so that the assumption can be made that the results from a service test are the same results that would be achieved if the weapons were tested in combat. The Test Concepts are described in detail in Annex A. The general objectives of the antitank methodology study are:

> To develop and evaluate methodologies for the operational testing of Infanty-associated antitank weapons systems under quasi-combat conditions.
>
> To identify those factors which are critical in testing and comparative evaluation in such an environment.
>
> To obtain field test data as a basis for establishing valid measures of system effectiveness.
>
> To develop objective standards for comparing system effectiveness.

This project analysis will be followed by a combat-oriented field experiment in which the major factors will be studied empirically. The aim is to increase the validity and efficiency of weapon system performance evaluation by incorporating, to the extent possible, the variables that influence combat effectiveness; and to eliminate from consideration those variables which have little influence on combat effectiveness. The final product of the methodology study will be a set of test procedures and test facilities specifically designed to provide operationally valid data for the objective evaluation of antitank weapon systems. The plan of analysis for the antitank methodology study is shown in Figure 1.



PLAN OF ANALYSIS - ANTITANK

METHODOLOGY STUDY

Figure 1

Recommendation

THE OPERATIONAL EVALUATION OF WEAPON SYSTEMS

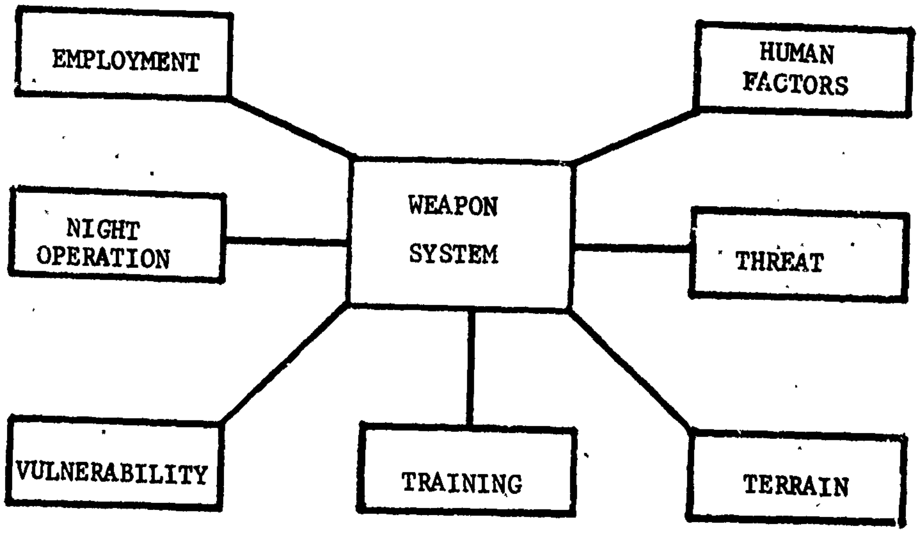
In operational testing, the test weapon or other combat support end item must be evaluated in terms of the total context in which the item will be used.

A weapon system alone is a meaningless entity since its effectiveness is dependent on where it operates, against whom, and how it is employed. In fact, the factors that can influence weapon system performance number in scores and the combinations of factors number in the hundreds.

The ultimate weapon test occurs in combat but the combat environment does not lend itself to testing. The measures of effectiveness are valid: number of enemy casualties, number of wounded casualties, and time to accomplish mission. But even in combat, cause and effect relationships are difficult to determine. For instance, outmanned and outgunned forces have been known to overcome extreme odds against survival. The cause could be ascribed to the strength of desire and esprit de corps or perhaps superior tactical position, or some combination of factors. Mission success or failure is dependent on too many factors to permit the establishment of causal relationships without adequate control. Further, data collection to establish an objective decision basis is extremely difficult and often costly to acquire. Lastly, the risk of loss where dependence is placed on an untested item may be high. Although the ultimate test of weapon or equipment effectiveness may occur in combat, combat is not the place where testing should occur.

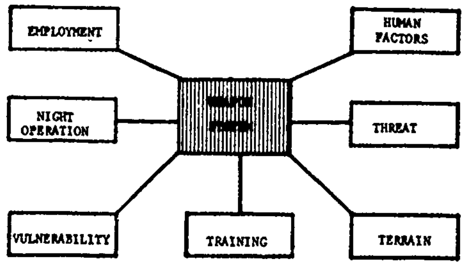
The solution to the problem of improved testing lays in the construction of the combat test environment. The aim is to provide an environment rich enough in combat factors to permit generalization of test conclusions to the real combat environment, yet with sufficient control to provide adequate objective data for the determination of cause and effect. A description of a proposed test facility appears in Annex B.

This analysis discusses some of the major factors that should be considered in operational testing of antitank weapons, and offers the rationale for and means of incorporating these factors. The factors discussed appear in Figure 2.



FRAME OF REFERENCE FOR THE OPERATIONAL TESTING OF ANTITANK WEAPON SYSTEM

Figure 2



Recommendation

THE WEAPON SYSTEM MODEL

Operational evaluation must focus on the performance of the weapon system.

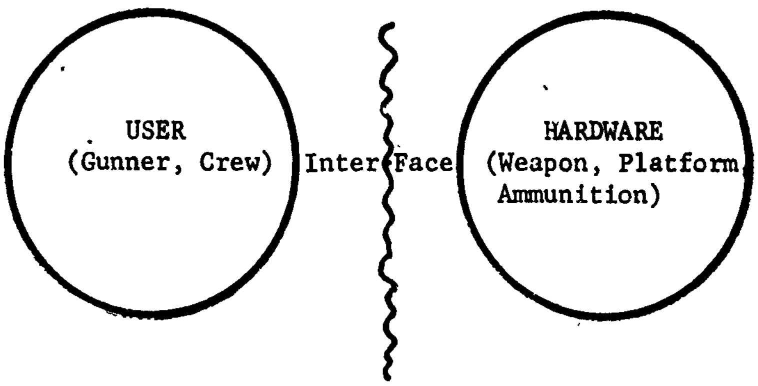
Prior to the service test in the testing cycle, the emphasis in testing is focused on the weapon itself, the specific hardware under development. The parameters of particular interest include weight, recoil, chamber pressure, muzzle velocity, angular dispersion, ballistics, and ammunition terminal effects. During these prior tests, the firing is accomplished under rigidly controlled conditions by men who are experts in weapon development and testing.

When a new or modified weapon reaches the Infantry Board, it meets for the first time in the development cycle the last major component of a weapon system, its user. The testing now shifts emphasis from hardware-oriented tests to system-oriented tests. Consequently, at this point in time, a weapon ceases to be a weapon for operational purposes. It maintains an identity for accountability and maintenance purposes, but functionally it ceases to exist as a separate entity. It becomes a weapon system and, hence, testing must be oriented to the evaluation of weapon system effectiveness.

Similarly, the human component has received particular attention in his development. Attention has been paid to the classification of inherent capability, physical condition, morale, and development of specific skills. Once selected as a component of a weapon system for test purposes, he too ceases to exist as a distinct entity except as a typical representative of a broader population. Measures such as weight, calorie consumption, IQ, and visual acuity, which describe his characteristics, cease to have meaning as long as he is

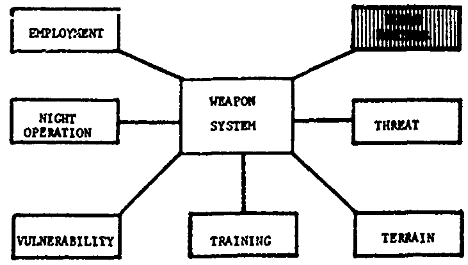
a typical representative and as long as normal differences in these characteristics do not have an appreciable effect on system performance. Should members of either the user or the hardware components of the model have specific characteristics that enhance or degrade system performance, then attention must be focused on those characteristics. These are discussed later.

The weapon system can be defined as consisting of two major components, the user and the hardware. Figure 3 is a figurative presentation of the weapon system model. Since the operational service test is system oriented and primarily considers the two major components only as a weapon system, recommendations as a result of operational service tests should normally be based on system performance. Consequently, system performance focuses heavily on how the user and the weapon function together as a system. This area of interest is called the man-weapon interface, and is referred to repeatedly throughout this analysis.



FUNCTIONAL MODEL OF A WEAPON SYSTEM

Figure 3



Recommendation

HUMAN FACTORS - MAN-MACHINE MODEL

The man-machine aspect of antitank weapon system performance should be quantified using the appropriate measures of effectiveness.

Human factors considerations pertinent to the conduct of weapon systems testing fall into several broad categories which will be discussed in the following three sections. These are the man-machine relationship problem, individual and crew proficiency, the imposition of combat stress, and motivation. Generally, these factors are not as subject to rigid experimental control as are other aspects of test procedures, so it is necessary to design means of minimizing any bias that could result in test data from the impact of these variables.

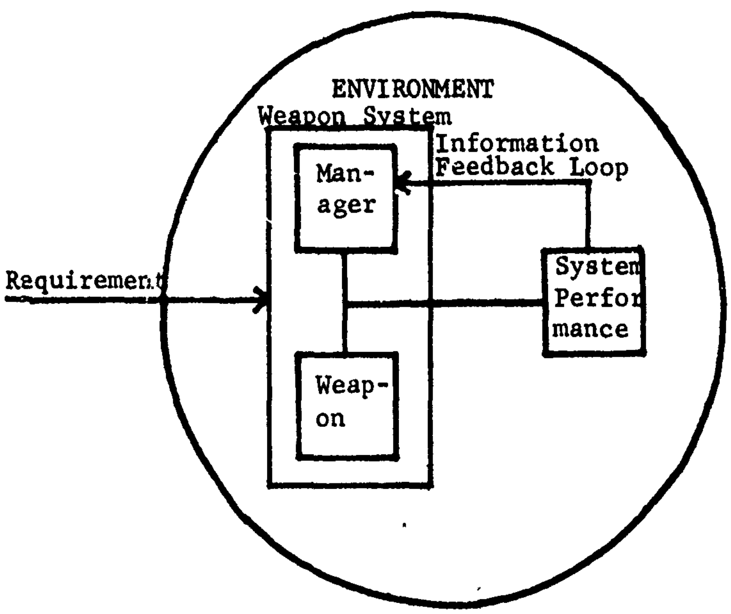
In the weapon system model, the man component of the system can be referred to as the manager, of the weapon component. His function is to manage the resources under his control to achieve the system's goals. The manager's performance is a product of many factors: how well he can operate the weapon, how much he wants to get the job done, and under what conditions he must work. The basic model is shown in Figure 4. Human factors focus on the manager component of the weapon system.

The human perceives the external world through his senses. The information he receives guides his actions in accordance with his assumed goals. One key to performance is related to the rapport which he develops with the weapon system of which he is a part. The hardware must be designed to interface with the human without placing any restrictions on the use of the senses to provide maximum effectiveness. A gun platform such as a recoilless106-mm rifle is an example of the conflict that can arise. To operate a weapon system, that is to use weapon-mounted sights and aim the weapon, the human must physically be on or near the platform. Yet the platform is not conducive to smooth human performance. Vision is obscurred by smoke and dust. Hearing is impaired by muzzle blast and equilibrium is affected by recoil of the weapon and bucking of the platform. In

the case of armored vehicles, there are further limitations due to restricted vision. Use of the sights and aiming actions are affected by target visibility and motion causing changing lead angles and interruptions of direct line of sight. The function of the weapon manager in handling the weapon is extremely complex even when outside influences, such as incoming fire from the enemy, are ignored.

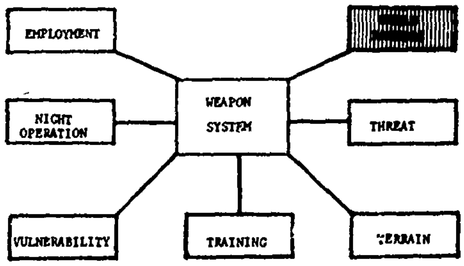
Measures must be found to quantify this management aspect of the weapon system if maximum system performance is to be achieved. Accuracy and responsiveness are the two major areas of consideration. Accuracy is a measure of the ability of the manager to estimate target parameters and use the sights for initial firing. Responsiveness is a measure of the ease with which the task is accomplished, and can be quantified with such measures as time-to-first-round and time-between-rounds. Measures that fulfill these requirements are described in a small arms methodology study report entitled "Antitank Methodology Review," US Army Infantry Board, April 1970.

The Methodology Review considered each combat action (Annex C) that would be required of an antitank weapon system and reduced these actions to a set of critical combat tasks (Annex D). Appropriate measures for each task were then suggested (Annex E). Antitank Experiment I should focus heavily on the further development of these measures. Understanding the weapon system model depends on how well the man-machine interface can be quantified.



MANAGER CONCEPT OF THE WEAPON SYSTEM

Figure 4



Recommendation

HUMAN FACTORS - COMBAT REALISM, MOTIVATION, AND STRESS

Stress induced by causes other than fear to provide increased combat realism should be avoided until more is known about the relationship between artificial stress and motivation.

Introduction of combat realism into a test environment is recognized as a major problem to which no completely satisfactory solution has been found. Simply stated, no adequate method has been devised to present the test subject with a credible threat to his life in a simulated combat situation wherein only the subject's side employs live fire. Hence, the basic motivations of individual and unit survival may be largely absent and must be replaced by alternates.

Generally, stress can be introduced by requiring the subject to conduct monotonous and repetitive tasks in the presence of constant distractions, by requiring the performance of complex tasks under severe time constraints, by requiring decisions in the presence of excessive and often irrevelant information inputs (information overload), and by sleep deprivation.

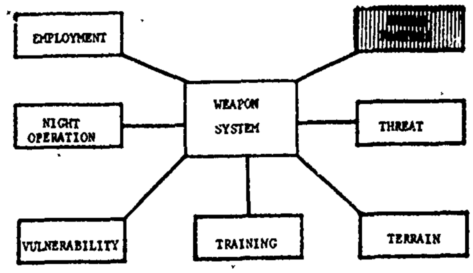
However, most of the above substitutes have a derogatory effect on motivation, a factor of prime concern in combat and during weapon testing. Consequently, stress-inducing techniques have dubious value in the service test. The trade off between the added realism provided by stress-induced subjects and the possible reduction in motivation should be studied further before stress provided by factors other than fear are introduced into the service test. Until this relationship is more thoroughly understood, stress should be de-emphasized and other combat realism inducing techniques emphasized. The paragraphs that follow provide rationale for introducing other types of combat realism into the test situation.

Living has been referred to as a kind of game. It has sets of rules, written and rewritten, which, when followed, lead to its successful conclusion. In fact, the major difference between the real world and a game is the value of the stakes. In games, as well as in

life, the rewards can vary from large material gains, to simple satisfaction and, further, to avoidance of discomfort. At some point, as the stakes climb in value, a game ceases to be a game. The point at which this occurs is not fixed. It varies among individuals and it varies with the same individual as a function of changing conditions such as attitude and well-being.

People can be classed according to a need to achieve and the characteristics displayed by high-need achievers and low-need achievers remain relatively constant over a broad spectrum of games. Consequently, highly motivated individuals can be expected to perform close to their capability limits whether in games or in the real world. The characteristic that cannot be accounted for is the adrenalin augmented response that is produced by extreme fear. However, this response is also uneffected by stress substitutes such as fatigue and boredom. Instead of duplicating the extreme and/or erratic responses, substitute stress will likely reduce motivation from a near maximum for each individual's need-achievement level to some lower level. The aim is to duplicate combat performance; the result of induced stress will likely move the individual away from that aim.

The operational service test should use test subjects that are alert and well motivated. Motivation can be enhanced by making the test situation as near to combat as possible. The test subject should perform actions similar to those performed by the combat soldier. Targets should simulate combat targets, elusive and difficult to hit. Distractions such as adjacent firers, artillery and small arms simulators would assist in making the game more real. The test soldier should be combat equipped and the game should include preliminaries such as a briefing prior to a patrol or defensive position preparation prior to an expected attack. The fact that performance will be measured, and compared to other individuals or groups should be related to the test soldier. Lastly, the direct effects of the soldier's efforts should be fed back to the soldier in real time; e.g., the dropping and/or smoke release of a target that was hit would indicate to the test soldier that he put together the correct set of required functions. It should be stressed, however, that the scoring and reward/punishment schemes should not be allowed to become a game in themselves and to obscure the overall test objective. The test soldier should always be aware of his objective. He should, for instance, successfully defend his position to the best of his ability and not simply try to produce maximum rate of fire.



Recommendation

HUMAN FACTORS - INDIVIDUAL PROFICIENCY

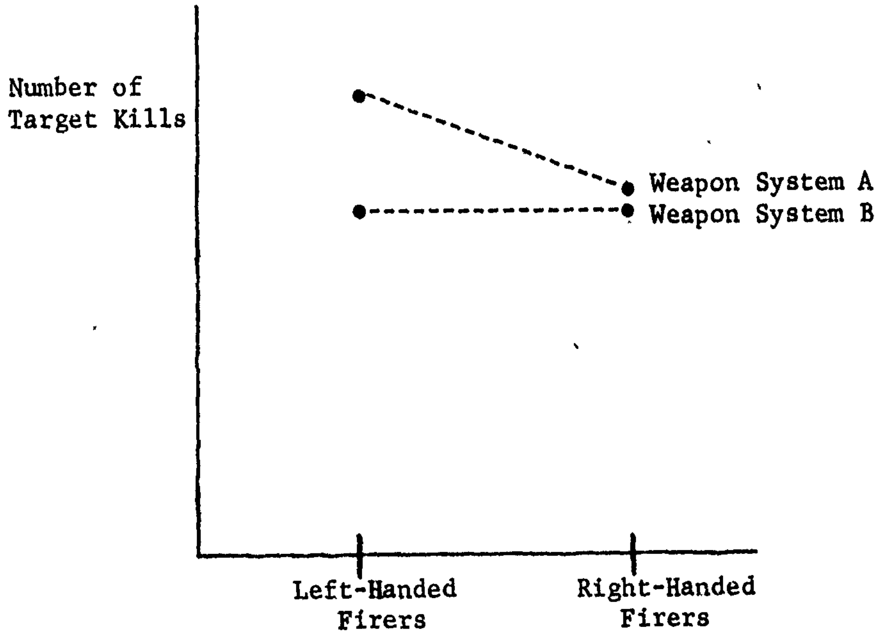
> Detection of interaction effects may provide a means for improving weapon system performance by concentrating on individual differences.

Once the individual has been selected as a component of a weapon system, he ceases to be a separate entity from a testing standpoint as long as he is a typical representative of the user population. This statement is generally true until some individual characteristic is found to have a significant effect on weapon system performance. Normally these differences are minor and have a corresponding minor effect on weapon system performance. Uniformity in proficiency is also enhanced by training procedures. Further, test personnel are selected on the basis of being close to the norm for the particular specialty area. The result of training and selection procedures is that the indivdual selected has a reasonably representative proficiency level normally expected of combat troops. Selection should always be based on MOS, experience in MOS, and proficiency and duration of combat experience.

Even with all of the above safeguards, occasionally some characteristic of human component of the weapon system, when varied, will have a significant impact on system performance, especially in the comparative testing of such complex weapon systems as the TOW, in which minor differences in operator proficiency can account for major differences in performance.

The existence of interactions between independent variables over some performance variable may be an important aspect of the man weapon interface. Care must be taken to insure collection and incorporation of as many data points as possible into the analysis of performance data so that interaction effects if present can be found. Particular attention should be paid to such parameters as prior experience (number of rounds fired on the test and similar weapon systems), dexterity, and visual acuity.

Figure 5 shows a hypothetical interaction between a human factor and weapon system performance. It can be interpreted as follows: left-handedness has no apparent effect on performance of weapon system B; however, left-handed firers are significantly better in terms of target kills with weapon A. This indicates that there is some factor in the manner in which the left-handed gunner interfaces with weapon A that significantly effects performance. At this point the rationale for the difference must be subjectively provided. It may, for example, be the position of the traverse wheel with relation to the firers position. Cause and effect relationships can be determined objectively but further testing is necessary.

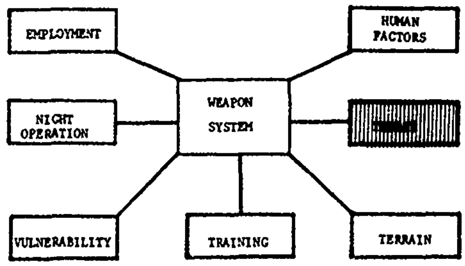


INTERACTION BETWEEN OPERATIONAL

PERFORMANCE (number of target kills)

AND LEFT-HANDEDNESS

Figure 5



Recommendation

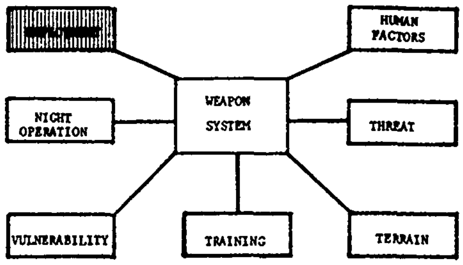
THREAT

Target realism is a necessary component of the operational evaluation of antitank weapon systems.

During the expected life of a weapon system, which normally varies from 10 to 20 years, the threat against which the weapon system may be used can be expected to change. Most of the conflicts in the world tend to occur between developing nations. Measures of politic-economic development and geographic position are indicators of a nation's ability to wage sustained warfare and are indicators of potential trouble spots. These analyses define the type and capability of the enemy and the terrain most likely to be engaged in future conflicts. Projected over the life of a weapon system, threats can be defined. Weapons are designed and engineered to perform against these threat-environment combinations; tests designed to produce the most efficient weapon systems should receive the same considerations. The test environment should incorporate as many real world factors as possible.

Targets should reproduce capabilities of potential enemy weapon systems. For example, if enemy armor or projected armor is expected to have a cross-country speed of 25 mph during fire and maneuver, targets should be able to attain speeds of at least 25 mph. Realistic target speeds require gunners to estimate lead-angle requirements. Current doctrines that prescribe exposure times and engagement techniques must be analyzed and incorporated into target actions; wire guided AT missiles that require X seconds to travel 2000 meters are useless against an enemy that keeps exposure times to less than X seconds at 2000 meters. Target size and engagement ranges should duplicate potential enemy weapon systems so that such factors as range estimation, image size versus reticle size, and image size versus field of view come into play. Contrast between target and target background should be realistic and hence dictates that targets use appropriate color camouflage schemes.

Empirical testing may permit the reduction of some of these factors and should be attempted if the cost to duplicate some aspect of a realistic enemy target is prohibitive. Further, the type of target action should be related to the most combat actions that the enemy will probably use. The combat actions are delineated in Annex C.



Recommendation

EMPLOYMENT

> Employment of weapons systems in the operational service test should duplicate as many combat actions as possible.

Antitank weapons fall into three categories: light, medium, and heavy. For the most part the weapons are direct fire or line-of-sight systems. The employment of antitank weapons is somewhat varied depending upon the size and type (missile vs conventional) of the weapon and the tactical situation. However, there are certain overriding principles which govern the successful use of organic and attached antitank weapons for small units (squad, platoon, and company). These units will habitually have certain combinations of antitank weapons to employ. Regardless of the number and types of antitank weapons a unit has, it should strive for the following:

Antitank weapon positions which provide good fields of fire out to the maximum range of the weapon system

Antitank weapons positions which are mutually supporting.

Antitank weapon positions which provide all-around antitank defense in depth.

Selection of alternate and supplementary positions which allow weapon crews to displace frequently and rapidly without losing effectiveness.

Local security for antitank crews which is integrated with other elements of the unit.

Seperation of the tanks from the accompanying Infantry by using artillery and small arms fire.

Concentration on the tanks initially using the principle of engaging the most dangerous target first.

Isolation to engage the tanks separately when individuals or small units are forced to engage tanks.

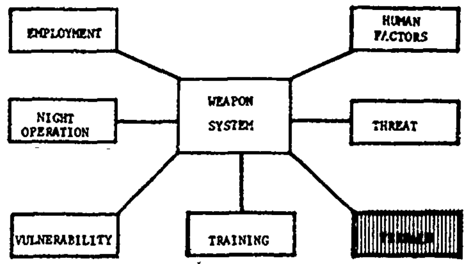
Engagement should be made where tanks are most channelized and where freedom of movement is limited.

An analysis of combat actions to achieve the above shows that firing is normally done from either prepared stationary positions or positions that take advantage of natural cover and concealment. To duplicate these basic actions the test facility should incorporate at least three firing positions with an action scenario requiring the crew to move into the first defensive positions for the initial target engagement. After engaging targets, the crew moves forward to occupy alternate positions. During the move, the crew should be presented with targets of opportunity that require hasty responses from the crew members. After the alternate positions are occupied the crew engages another set of targets, perhaps at reduced ranges. Finally, the crew displaces rearward and again while enroute is offered targets of opportunity. The move itself should be over unprepared surfaces to permit the occurrence of such operational problems as broken mounting brackets and sight misalignment. This short scenario will require the essential tasks of the combat actions listed in Figure 6. A more complete list appears in Annex C.

Frontal Assault	Retro Grade Operations
Advance to Contact	Area Security
Recon Patrol	Hasty Defense
Security of Moving Column	Deliberate Defense
	Combat in Cities

PARTIAL LIST OF REPRESENTATIVE COMBAT ACTIONS

Figure 6



Recommendation

TERRAIN

> The type or severity of topography appears to be relatively unimportant in operational testing as long as it is rich enough to permit the gunner to estimate factors such as range, speed, lead angle, and near miss distance in a realistic manner.

All combat is associated with some type of terrain and steps have been taken to include terrain effects in the weapon testing cycle. Extreme conditions are accounted for by the tropic, desert, and arctic test facilities. However, these extremes do not lessen the requirement for testing under less severe terrain conditions. (Topography, weather and vegetation are not independent and, subsequently, are included in the meaning of the word terrain as used here). A review of the impact of terrain conditions indicates that, although desirable, testing under many types of terrain may be unnecessary. In other words, it appears more important to prescribe the do not's rather than the do's when incorporating specific terrain requirements into operational weapon evaluation. The terrain should not be a flat, featureless, KD type of range. These ranges do not task the gunner/operator to estimate ranges, target speeds, lead angles, miss distance feedback data, and dust signatures of enemy weapons in a realistic manner. Any type of uneven natural terrain rich enough in surface features to provide a normal influence on the tasks referred to would provide an acceptable test environment. In fact, terrain can be enriched with the addition of reference points such as small hills, brush clumps, or scarred areas at least to the extent permitted by time and cost constraints. Terrain features considered minimal are summarized in Figure 7.

In addition to providing a normal backdrop for the tasks the gunner must perform, the selected terrain must have a safety fan to permit target tracking and shifting of targets laterally. It must provide for the realistic target movement described under Threat and realistic weapon employment described under Weapon Employment. Again, empirical testing may permit the simplification of these requirements. A complete description of a proposed anti-tank weapon system test facility appears in Annex B.

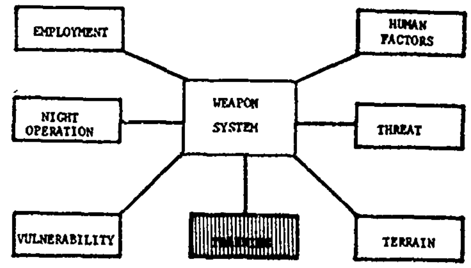
Engagement ranges from
100 to 3000 meters.

Lateral dispersion of
targets of 130 mils.
(This figure exceeds
the field of view of
most optical sites).

Natural, moderately
undulating terrain with
prominent vegetation and
natural topographic fea-
tures.

MINIMUM TERRAIN REQUIREMENTS

Figure 7



Recommendation

TRAINING

New training procedures should be developed for test weapons prior to evaluation in the operational service test.

Thus far in this analysis emphasis has been placed on the weapon operator or gunner. However, crew effectiveness depends heavily on the ability of a group of men to perform together in a smooth and efficient manner. A crew works as a team and, consequently, has a common set of objectives. A gunner or operator normally lays and fires the weapon. Before this sequence can begin, a crew must position the weapon platform accounting for any idiosyncrasies, prepare the platform for recoil absorption, if necessary, prepare the ammunition, and load the weapon. Thus, the effectiveness of a crew-served weapon is dependent on how well each of these tasks is performed.

The training procedures for crew-served weapons need close examination before crews are trained for participation in operational service testing. The normal procedure for preparing crews for service tests follows this pattern:

(a) Previously trained antitank gunners are selected and trained in the new weapon system.

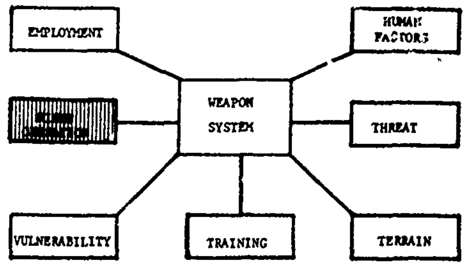
(b) When a new 132-mm RR is to be tested, the FM for the most similar weapon system, in this case the 106-mm RR, is consulted and a training schedule prepared.

(c) When existing training procedures state that dry fire practice requires 2 hours and gun aiming practice requires 4 hours, the new training schedule states the same thing even though the weapon configuration may be quite different.

Even worse, it is highly probable that the procedures stated in the manual were not developed for the current system but are carryover's from earlier generations of weapon systems.

Each new weapon system needs to be evaluated for its unique needs, and training procedures to optimize crew performance should be developed with this goal in mind. Side-by-side tests using two different training procedures may be necessary to determine optimum training techniques. This effort will not only insure better trained crews for operational service tests, but will permit the introduction of new, more effective training techniques along with the issue of the weapon. The training gap that usually occurs with the introduction of new weapons will be eliminated. Combat crews will not be trained on new weapons with old weapon training methods for that period of time that it takes to realize the problem exists plus the time it takes to implement improved training procedures.

Operational measures of effectiveness for crew performance are scarce. Time to first round and time between rounds are good indicators that a potential problem exists. However, observation by experienced people and standard time and motion techniques are more suitable for isolation of the problem. Motion pictures or closed circuit television with stop action and instant replay capabilities may be extremely valuable aids.



Recommendation

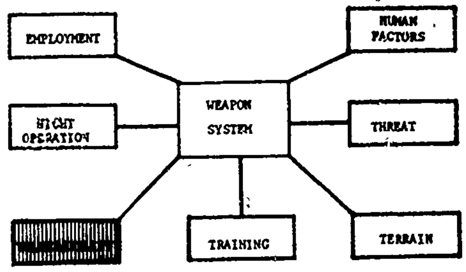
NIGHT OPERATIONS

An all weather, day/night test facility should be developed to fulfill future operational antitank weapon system test requirements.

With the development of night vision devices and improved artificial illumination techniques, night combat operations are becoming increasingly important. Consequently, operational testing should include an evaluation of the compatibility of a new weapon system and the night combat environment.

Antitank weapons systems equipped with or operated in conjunction with low-light level vision aids, such as passive night vision devices or infrared detectors, should be tested in night operations. Such tests are critical in evaluating systems which use image intensifiers, because such equipment is subject to whiteout by muzzle flash, shell detonations, artificial light sources such as vehicle headlights, and other phenomena resulting in transient increases in local or ambient level of illumination.

Operational testing at night is a relatively new area of interest and contains many unknowns. Methodology testing is one means of isolating the important factors and reducing them to manageable numbers.



Recommendation

VULNERABILITY

Develop measures which describe test weapon system exposure to enemy fire, while the weapon is performing various combat tasks, to provide quantitative, comparative data on weapon system vulnerability.

In order to be effective in combat with direct fire weapons, at least some degree of exposure of the crew and the weapon is necessary. There are two exposure parameters for direct fire weapons. These are the size of the area exposed and the period of time the exposure lasts. Against indirect fire weapons, the period of time the weapon is exposed becomes less important while hardness increases in importance.

These measures are not difficult to obtain and need no further evaluation in field experimentation. If the weapon components or crew members are vulnerable to different types of enemy fire during the period of target acquisition, tracking, firing or launching, and guiding, measures expressed in time of exposure and size of vulnerable area should be gathered and added to the data base for weapon system evaluation. The problem of incorporating the data into usuable form is more formidable, since the effects of return fire are difficult to quantify and weigh against other decision parameters.

A suggested method is to build a small 2-sided combat model in which the test weapon system is committed against a representative set of enemy weapons on a side-by-side test basis with a standard weapon such as the 106 recoilless rifle. Exposure parameters must be expressed in terms of probability of detection, acquisition, hit, and kill for model input. Two sets of probabilities will be necessary: one set to be used in the combat model while the weapon is passive, and the other after the weapon system has begun to engage the enemy. This procedure will include the effects of the weapon signature, an important consideration in the combat environment. The required input probabilities can be determined empicially or perhaps taken from existing data on detection.

SUMMARY

The cost and usually limited availability of prototype AT weapons dictate that as much valuable and useful information as possible be generated from each round fired.

As a result of this analysis, several recommendations have been offered for consideration to improve antitank test methodology. Some of these recommendations need no further evaluation and can be incorporated directly into operational service tests. Others are less straightforward and need further evaluation to determine whether the effort required to incorporate them is worthwhile in terms of the expected improvement in test data.

Following the edict that states the methodology study is responsible for isolating and incorporating influencing factors, this analysis recommends a field experiment to determine the value of some of the factors. Those factors which prove to be of little value in discriminating between competing weapon systems can be dropped from the test situation without loss in data validity. Others which prove to be important weapon system performance discriminators can be concentrated on providing the most efficient evaluation possible.

Another reason for recommending that an antitank experiment be accomplished is to make use of the knowledge and instrumentation that have been developed during the small arms portion of the methodology. The sensors, recording equipment, and technical support are already on hand and can be programmed for use in supporting an antitank field study. If a field study is desired, it would be cost effective to do it during the methodology study.

Another consideration is the fact that antitank weapons tests are characterized by low rates of fire using relatively expensive rounds, particularly when dealing with wire guided systems. Both of these factors will limit the use of test replication as a means of achieving statistical significance, and place a premium on thorough test design.

Lastly, the cost of new AT systems such as DRAGON is such that an investigation into improved performance quantification techniques is certainly warranted. Methodology gained from a field experiment could significantly improve the data base in future tests. Quantification of influencing factors is the first step in building simulation models, which in turn could be of use in designing and testing future weapon systems, in wargaming to examine battlefield effects, and in evaluating such factors as terrain and vegetation variations mathematically. The ultimate effect would be a much broader evaluation of performance without the expense in time and dollars of additional field experimentation.

Recommended as subjects for Antitank Experiment I are stress, fatigue and motivation studies, night operation experimentation techniques, target parameter effects (speed, exposure time) and a vulnerability study. Quantification of any of these subject areas will significantly improve the weapon system frame of reference. Each of the steps necessary for completion of Antitank Experiment I appears in PERT format in Annex F.

Recommended for direct incorporation into AT weapon system tests without further evaluation are man-machine performance measures for such tasks as tracking and range estimation, improved target realism, and operational employment.

ANNEX A

TEST CONCEPTS

1. INTRODUCTION

A systematic staff study entitled "Infantry Antitank Weapon Methodology Review" was completed prior to the start of the methodology study for antitank weapons to provide guidance in outlining the scope of the program. Combat actions were reduced to a set of combat tasks required by crew members to accomplish the specific actions. These tasks were further categorized by sets of measures that could be used in an operational evaluation of weapons systems. The measures were then defined and correlated back to the set of combat actions by category. This review provided much of the background for the project analysis. Portions of the review are presented in subsequent annexes as outlined below. These annexes will be a valuable asset in actual test facility construction, during the design of specific methodology field experiments, and during operational service tests of antitank weapons and equipment.

Combat Actions - ANNEX C

Reduction of Combat Actions - ANNEX D

Measures of Effectiveness - ANNEX E

2. TEST CONCEPTS

Test concepts to be employed on the antitank test range are predicated upon anticipated weapons systems requirements in the 1970-1' 5 time period. Test concepts are based upon three classes of weapons currently in use or in an advanced state of development:

a. 106-mm Recoilless Rifle, M40

b. Light Assault Weapon, M72

c. Heavy Assault Weapon, TOW

Other weapons (e.g., 90-mm recoilless rifle, 120-mm recoilless rifle, Dragon ENTAC) which are similar in basic concept to those mentioned above should be adaptable to the test facility without significant alternations in test procedures or range instrumentation. A brief description of a test procedure is presented for illustrative purposes.

3. TEST PROCEDURES

As indicated above, the 106-mm recoilless rifle, M40, is the suggested baseline weapon system for this class of antitank weapon. Tests will be conducted using the .50-caliber spotting rifle (M8C) to estimate target range and bearing. A typical test might proceed thus:

1. Test observers assume their stations and a ready signal is issued to the test officer. The weapon crew emplaces the weapon and any visual aid devices appropriate to the scenario.

2. Target motion is initiated out of view of the weapon crew after a delay, the duration of which is not known to the crew.

3. The following sequence of events occurs, and the corresponding times are logged by a test observer or data recorder:

   a. Target appearance

   b. Target identification

   c. Fire spotting round

   d. Repeat (c), if a miss results

   e. Hit on target by spotting round

   f. Fire antitank round

   g. Reload and repeat (f), if miss

   h. Hit on target

   i. Target disappearance or halt

Engagement ranges will be varied to provide a realistic evaluation of P_K as a function of range. A suitable choice of target course will provide a capability for evaluating aiming performance for a variety of viewing angles and angular rates. The target presentations would be programmed to proceed until the weapon crew has revealed its presence as determined by an observer or the weapon commander, at which time the system would displace to alternate firing positions. Target presentations requiring firing while on the move would duplicate the tasks required in such actions as column security and advance to contact.

As engagement ranges are reduced, load and reload times and gunner accuracy become critically important. Results recorded during field tests could be simulated in a 2-sided wargame in which the effects of load times can be assessed operationally.

Tests of wire guided missile systems would proceed along similar lines, except that longer engagement ranges could be used. Test scenarios would be developed to evaluate other system capabilities such as the following:

Ability of the weapon crew to maintain track in the presence of temporary obscuration, changes in target aspect, and changes in target course.

Ability of the system to respond to high angular rates such as might be encountered in shifting targets subsequent to launch.

Ability of the automatic tracking equipment to maintain lock on the target in the presence of other visual/infrared sources and signal attenuation due to dust or smoke.

4. TEST VARIABLES

Three categories of variables will be considered on conducting antitank weapons systems methodology study: independent, dependent, and random. Variables within these categories are listed below:

Independent Variables - These are subject to control and are treated in the test or experimental design:

Weapon system

Engagement range

Target characteristics

Target course and maneuvers

Weapon location

Target exposure times

Weapon type

Round type

Crew proficiency

Target illumination

Light levels (night operations)

Dependent Variables - Measures of Effectiveness - A complete list of dependent variables was developed during the Infantry Board's Antitank Methodology Review (see Annex E). Definitions are provided for each measure and references are made to specific operational tasks where these measures may assist in the quantification process.

During Antitank Experiment I, this list of measures should be evaluated to determine how precisely combat actions can be measured. In cases where objective measures could not be provided, subjective evaluation is substituted as an effectiveness measure.

Random Variables

Weather

System Malfunctions

5. DATA REQUIRED

The measures of effectiveness will be based on several kinds of sensor collected data, which are discussed in the following paragraphs.

Target Hits - Each hit either by the spotting round or from the main armament or missile will be sensed and recorded to develop such measures as time-to-first-hit. Preferrably, the target should be divided into upper and lower halves: the upper half to represent a fire power kill and the lower half hit a mobility kill. A laminated honeycomb paper product has been tested and appears to be satisfactory as a target material. Aluminum foil or screen attached to both sides of the honeycomb material acts as a conductor for scoring hits. The honeycomb material acts as a dielectric. This material has been tested using the 106-mm round. The test results are reported in a USAIB Technical Memorandum entitled "Electronic Scoring Material for Antitank Ammunition" (see Annex G).

Miss Distance - Near-miss data can be obtained by acoustic instrumentation mounted on the target for hypersonic ammunition. An alternate scheme must be developed for testing missile systems. Photographic techniques appear to be within the present capabilities of the Infantry Board provided the magnitude of the test is small. Photographic data reduction is normally very time consuming.

Response Times - These are measures of time required by the anti-tank weapon crew to accomplish required tasks, including but not necessarily limited to target identification and acquisition, range estimation, weapon loading, emplacement of spotting rounds, target tracking, weapon reload, and target shifting. The simplest method of measuring response time is to employ an observer equipped with check list and stopwatch or event recorder. Correlation of data would be facilitated if the observer were further equipped with a device to transmit event data to the data collection center in real time.

Round Count - Accoustic systems can be used for conventional weapons and accoustic/electric should be considered for missile systems. The important factor is not to instrument the weapon in such a way as to interfere with its balance or handling characteristics.

Target Location - Location of the target within the moving target trace is required to describe accurately the conditions under which a P_K was calculated. Switches spaced along the target trace and activated by the target carrier as it passes over can be used to estimate target speed, exposure time, and range at the time of acquision, tracking, and firing by the crew.

Environmental Factors - Wind velocity and direction, ambient light, visibility, and other factors affecting mission performance should be measured objectively during each firing for possible correlation with performance.

ANNEX B

PROPOSED ANTITANK WEAPONS TEST FACILITY

1. GENERAL

Any tests of candidate weapons must be conducted on a reliable instrumented facility on which the two competing weapons can be operationally compared. The most ideal facility is one that provides the following:

a. Sufficient terrain on which to maneuver the tactical unit (weapons platoon, tank-hunter-killer team) to which the candidate weapons are normally assigned.

b. The ranges and safety fans necessary to test the maximum effective range of the candidate weapons.

c. Moving target system: track and wheel vehicles, personnel type.

d. Prepared defensive positions, defilade firing positions, and assault firing positions.

e. Point fire targets representing tanks, APC's, and bunkers.

2. DISCUSSION

The antitank range shown in Figure B-1 of this annex does not represent any particular piece of terrain at Fort Benning. The proposed range is merely an example of what an ideal antitank range should look like.

a. The range is designed to test the following combat actions.

(1) Deliberate Defense.

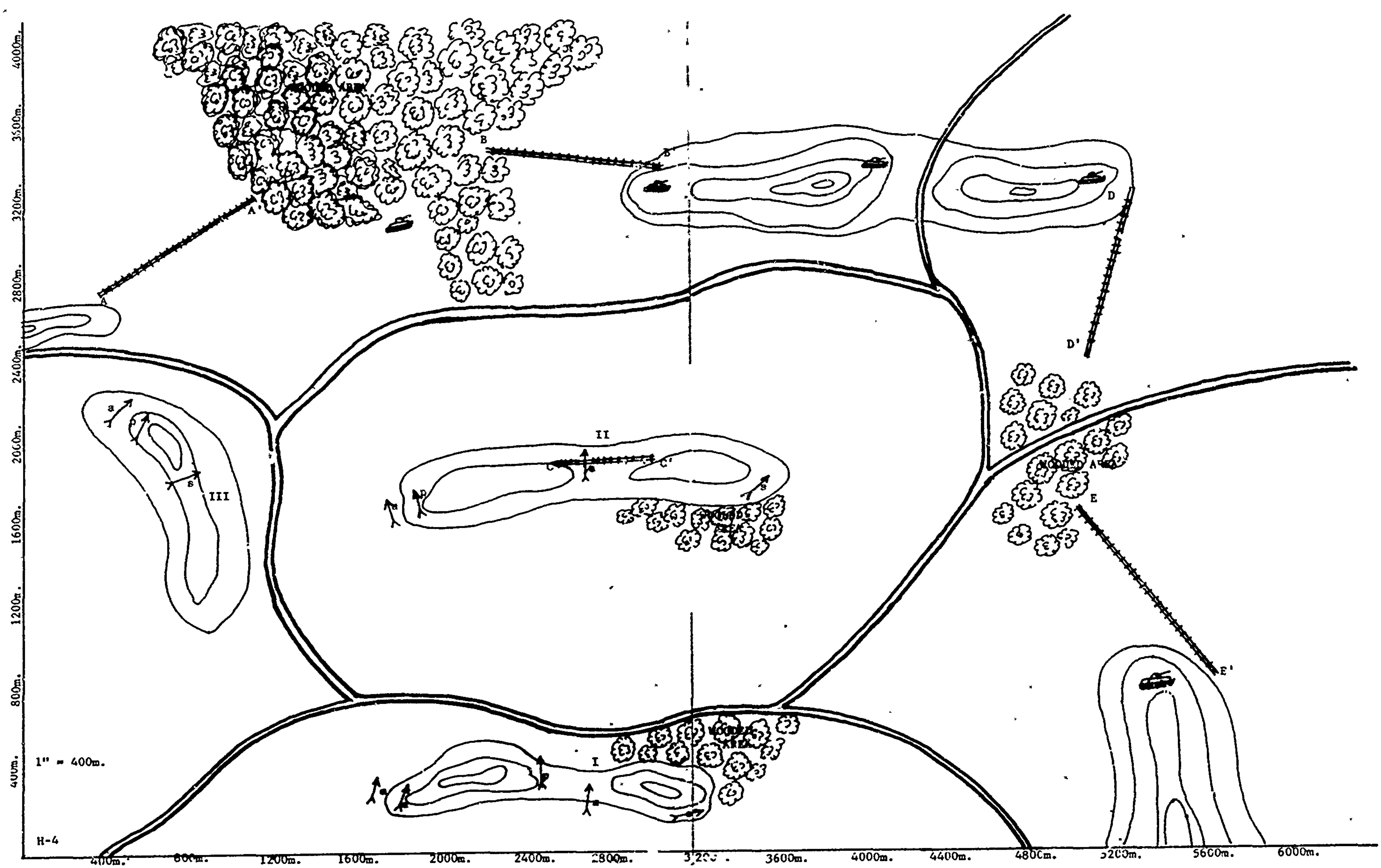
(2) Hasty Defense.

(3) Retrograde Operations.

(4) Fire and Movement.

(5) Tank-Hunter-Killer Operations.

(6) Advance to Contact.



4000m.
3600m.
3200m.
2800m.
2400m.
2000m.
1600m.
1200m.
800m.
400m.
1" = 400m.
H-4
400m.
800m.
1200m.
1600m.
2000m.
2400m.
2800m.
3600m.
4000m.
4400m.
4800m.
5600m.
6000m.
A
A'
B
D
D'
E
E'
C
C'
I
II
III

Figure B-1

The combat actions tested on the range comprise 6 of the 7 representative combat actions selected by this study (Annex C). The representative combat action "Combat in Cities" must be tested on another range due to special problems encountered in such a test.

b. A certain amount of crew training will be required upon receipt of a new weapon system prior to actual testing. This will include static firing and firing at a moving target. It will also include evaluation of training methods to insure that methods adopted for training of each crew, particularly if the weapon is new or has been modified, is suited to the test weapon. Crew training may have an impact on weapon system performance and must be given serious consideration prior to any operational evaluation. Range facilities for this training must be locally available and should not require the use of the projected test facility.

c. The proposed range (see Figure B-1) has 4 moving targets (A-A', B-B', C-C', & D-D'), 5 stationary tank targets (2 of which are in hull defilade and one is a fortified fixed position), and three different firing positions (A,B,C) with primary, alternate, and supplementary firing positions. All the combat actions listed under 2a can be performed on this range. Deliberate and hasty defense positions are available at firing locations A,B, and C. The ranges from firing location A satisfy the most extreme requirements of the present QMR's on heavy antitank weapons. Retrograde operations can be programmed using any of the numerous woodlines and firing positions as well as the road network for maneuvering. Fire and movement and tank-hunter-killer operations can both be demonstrated along with the advance to contact. The terrain and target locations permit a variety of test scenarios to be made.

d. In any combat situation, the enemy is anything but an exposed, passive receiver of friendly fire. The enemy can be expected to be elusive and to keep his own exposure times limited. Therefore, target exposure times (excluding fortified positions) should be realistic. This will help to insure that results of weapon system effectiveness tests will be indicative of combat results under similar conditions.

e. Conversely, exposure time of the test weapons systems should be a part of the evaluation procedure. The time which is required to acquire, track the target, and fire is an important consideration if the weapon system is exposed to enemy return fire during that period. Measurements of the degree and time of exposure should be a part of the system tests. The effects of this exposure period could best be determined by a 2-sided simulation model in which return fire can have direct effect on system performance. This is one area in which computer simulation models could effectively augment operational service tests.

ANNEX C

ANTITANK COMBAT ACTIONS

This review of combat actions deals with a wide variety of weapons (light, medium, and heavy antitank weapons) having varying capabilities. The combat actions considered do not all apply to each weapon system (for instance, the LAW would rarely be used in the combat action, combat outpost, and the TOW would probably not be used at all for tank-hunter-killer operations). The combat actions listed are designed to be all-inclusive and to cover antitank weapon employment under normal conditions. The combat actions list was prepared after researching pertinent doctrinal and training literature.

1. Combat Outpost	13. Fire and Movement
2. Delaying Action	14. Consolidation
3. Roadblocks	15. Exploitation
4. Retrograde Operations	16. Breaching Operations
5. Collapsing Defense in Withdrawal from LZ	17. River Crossing
6. Area or Position Security	18. Ambush
7. Hasty Defense	19. Advance to Contact
8. Deliberate Defense	20. Security of Moving Column
9. Counterattack	21. Search and Clear
10. Tank-Hunter Operations	22. Recon Patrol
11. Frontal Assault	23. Combat Patrol
12. Fire and Maneuver	24. Counterambush
	25. Combat in Cities

ANTITANK COMBAT ACTIONS

Figure C-1

ANNEX D

REDUCTION OF COMBAT ACTIONS

The primary purpose of the combat action concept table in Annex C is to provide a means of reducing the number of combat actions by combining those actions which show similar characteristics. A detailed study of the combat actions (see Figure D-2 in which 25 combat actions are shown) was undertaken. Through the review, the combat actions were reduced to 13 critical combat tasks with primary emphasis placed on the actions of the individual/crew weapon combination. Each critical combat task is considered relative to each category of antitank weapons (light, medium and heavy). The ranges mentioned (such as short, medium, and long) are relative to the weapon being tested and will take into consideration the weapon's minimum arming distance and maximum effective range (for instance, one antitank weapons minimum arming distance might be another's maximum range). The tasks are shown in Figure D-1.

Long range aimed fire on selected targets.

Medium to short range fire--supported firing position.

Medium to short range fire--unsupported firing position.

Rapid movement--rapid reload.

Medium to short range fire--rapid displacement.

Maximum aimed fire--minimum exposure to enemy fire.

Rapid reaction to suitable targets.

Deliberate methodical movement with detailed observation.

Anticipated short and/or medium range enemy contact.

Clear fields of fire.

Prepare and camouflage positions.

Put in and/or utilize existing barriers.

Conduct recon of withdrawal and occupation routes.

CRITICAL COMBAT TASKS

Figure D-1

TANK/ACTION CONCEPT TABLE

TASK	COMBAT OUTPOST	DELAYING ACTION	ROADBLOCKS	RETROGRADE OPNS	COLLAPSING DEF. WITHDRAWAL (LZ)	AREA/POSITION SECURITY	HASTY DEFENSE	DELIBERATE DEFENSE	COUNTERATTACK	TANK HUNTER KILLER OPERATIONS	FRONTAL ASSAULT	FIRE AND MANEUVER	FIRE AND MOVEMENT	REORGANIZATION AND CONSOLIDATION	EXPLOITATION	BREACHING OPNS	RIVER CROSSING	AERIAL ASSAULT	AMBUSH	ADVANCE TO CONTACT	SECURITY OF A MOVING COLUMN	SEARCH AND CLEAR	RECON PATROL	COMBAT PATROL	COUNTERAMBUSH	COMBAT IN CITIES
LONG RANGE AIMED FIRE ON SELECTED TARGETS	4	4	1 2 4	4	1		4	1 2 3 4	4		1 2 4	4	1 2 4	4	4	1 2 4	1			1 2 4	4					
MEDIUM TO SHORT RANGE FIRE---SUPPORTED FIRING POS.	2 4	2 4	1 2 4	2 4	1 2 4	1 2 4	1 2 4	1 2 3 4	1 2 4	1 2	1 2 3 4	1 2 4	1 2 4	1 2 4	4	1 2 4	1 2 3 4	1 2	1	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4	1 2 3 4
MEDIUM TO SHORT RANGE FIRE---UNSUPPORTED FIRING POS.	2	2	1 2	2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2		1 2	1 2	1 2	1	1 2	1 2	1 2	1 2	1 2	1 2	1 2
RAPID MOVEMENT---RAPID RELOAD	4	2 4		2 4	2 4					1 2	1 2 4		1 2 4		4	2 4	2 4	2		1 2 4	1 2 4	1 2 4		2 4	1 2 4	1 2
MEDIUM TO CLOSE RANGE AIMED FIRE / RAPID DISPLACEMENT	2 4	2 4	1 2 4	2 4	1 2 4		1 2 4	1 2 4		1 2	1 2 4		1 2 4		4	2 4	2 4	2	1	1 2 4	1 2 4	1 2 4		2 4	1 2 4	1 2
MAXIMUM AIMED FIRE---MINIMUM EXPOSURE TO ENEMY FIRE	2 4	2 4	1 2 4	2 4		1 2 4	1 2 4	1 2 3 4		1 2	1 2 3 4	1 2 4	1 2 4			1 2 3 4	1 2 3 4		1							1 2 4
RAPID REACTION TO SUITABLE TARGETS		2 4	1 2 4	2 4	2		1 2 4	1 2 3 4	1 2 4	1 2	1 2 4	1 2 4	1 2 4		4			1 2	1	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4
DELIBERATE METHODICAL MOVEMENT WITH DETAILED OBS.										1 2									1	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4		1 2 4
ANTICIPATED SHORT AND/OR MEDIUM RANGE ENEMY CONTACT							1	1 2 3 4	1 2	1 2	1 2 4	1 2	1 2 4				1 2 4		1	1 2 4	1 2 4	1 2 4	1 2 4	1 2 4		1 2 4
CLEAR FIELDS OF FIRE	2 4	2 4	2 4	2 4	2		1 2 4	1 2 3 4						1 2 4					1							1 2 4
PREPARE AND CAMOUFLAGE POSITIONS	2 4	2 4	2 4	2 4		1 2 4	1 2 4	1 2 3 4						1 2 4					1							
PUT IN AND UTILIZE EXISTING BARRIERS	2 4	2 4	1 2 4	2 4		1 2 4	1 2 4	1 2 3 4		1 2									1							1 2 4
CONDUCT RECON OF WITHDRAWAL AND OCCUPATION ROUTES	2 4	2 4	2 4	2 4	1 2 4	1 2 4	1 2 4	1 2 4		1 2									1							

1. Light Anti-Tank Wpns. (M-72) LAW
2. Medium Anti-Tank Wpns. (M-67) 90mm
3. Heavy Anti-Tank Wpns. (M-40A1) 106mm and TOW GROUND MOUNTED
4. VEHICLE MOUNTED

*These weapons are merely representative samples of the family of weapons having similar characteristics.

Figure D-2

The review reveals that certain critical combat tasks are common to one or more combat actions. For the purpose of analysis the combat actions were divided into two distinct groups, mobile operations and static operations, thus allowing further reduction in combat actions.

The following discussion and analysis briefly describes each combat action and shows the basis of similarity of critical combat tasks performed. Figure D-2 shows the relationship between the combat actions and combat tasks as a function of AT weapon types (light, medium, and heavy). The combat actions can be grouped into a smaller number of representative combat actions each of which displays similar characteristics (in this case, measurable characteristics) of its subelements. This reduction allows a more complete and comprehensive study to be made of the representative combat actions and provides a more manageable set of parameters for use in the methodology evaluation.

a. Static operations are:

Deliberate Defense

Fire and Maneuver

Hasty Defense

Area or Position Security

Reorganization and Consolidation

Ambush

Combat Outpost

Roadblocks

(1) Deliberate Defense. The combat action, deliberate defense, is a well-planned relatively permanent defensive posture. It is characterized by thorough position preparation using every means available to defend. Reference to the task/action concept table shows that the majority of the critical combat tasks considered are performed in the deliberate defense. For this reason this combat action will be considered as a representative action which displays all the characteristics of other combat actions to be discussed later in this study.

(2) Fire and Maneuver. This combat action considers only the actions of the base of fire elements and not the maneuver element (to be discussed later in the mobile operations section under the heading of Fire and Movement). The base of fire element is primarily

responsible for providing fire support for the maneuver element. Normally the base of fire element is in a static position for a fixed period of time and is characterized by aimed fire from a stationary position. Reference to the task/action concept table shows that all measurements required for fire and maneuver are included in the combat action, deliberate defense. For this reason the combat action, fire and maneuver, is combined as being a subelement of the representative combat action, deliberate defense.

(3) Hasty Defense. The hasty defense is an example of a defense in which little time has been allowed for position preparation and planning. Normally the hasty defense is used for a relatively short period of time (after which it either evolves into a deliberate defense or becomes an offensive or retrograde operation). The hasty defense is a representative combat action displaying many characteristics of other combat actions.

(4) Area or Position Security. This combat action deals with the security of a small area (such as the site of a downed helicopter or the area around a water point). In this instance it is assumed that the security element will only be in position for a relatively short period of time and will not fortify itself to the extent that it might in a more permanent situation. The critical combat tasks performed are similar to those performed during the hasty defense and can all be measured under the heading of hasty defense.

(5) Reorganization and Consolidation. Reorganization and consolidation pertain to actions taken to organize and strengthen a newly gained objective. Initially, a hasty defensive posture is assumed to ward off possible counterattacks. Consideration of the critical combat tasks performed during the consolidation indicates that this combat action is characterized by minimum position preparation time under threat of imminent enemy attack and medium-to-short-range aimed fire. Since the tasks are similar to those performed in the hasty defense, it will be evaluated under that heading.

(6) Ambush. The combat action, ambush, deals with relatively close range fires from a mobile force. The individual/crew weapon actions are included in the combat action, tank-hunter killer operations, as well as in the hasty defense. The only critical combat task not covered in the combat action, hasty defense, is the task involving "deliberate methodical movement with detailed observation." This task is covered, however, in the combat action, tank-hunter-killer operations. The combat action, ambush, is included as a subelement of both hasty defense and tank-hunter-killer operations.

responsible for providing fire support for the maneuver element. Normally the base of fire element is in a static position for a fixed period of time and is characterized by aimed fire from a stationary position. Reference to the task/action concept table shows that all measurements required for fire and maneuver are included in the combat action, deliberate defense. For this reason the combat action, fire and maneuver, is combined as being a subelement of the representative combat action, deliberate defense.

(3) Hasty Defense. The hasty defense is an example of a defense in which little time has been allowed for position preparation and planning. Normally the hasty defense is used for a relatively short period of time (after which it either evolves into a deliberate defense or becomes an offensive or retrograde operation). The hasty defense is a representative combat action displaying many characteristics of other combat actions.

(4) Area or Position Security. This combat action deals with the security of a small area (such as the site of a downed helicopter or the area around a water point). In this instance it is assumed that the security element will only be in position for a relatively short period of time and will not fortify itself to the extent that it might in a more permanent situation. The critical combat tasks performed are similar to those performed during the hasty defense and can all be measured under the heading of hasty defense.

(5) Reorganization and Consolidation. Reorganization and consolidation pertain to actions taken to organize and strengthen a newly gained objective. Initially, a hasty defensive posture is assumed to ward off possible counterattacks. Consideration of the critical combat tasks performed during the consolidation indicates that this combat action is characterized by minimum position preparation time under threat of imminent enemy attack and medium-to-short-range aimed fire. Since the tasks are similar to those performed in the hasty defense, it will be evaluated under that heading.

(6) Ambush. The combat action, ambush, deals with relatively close range fires from a mobile force. The individual/crew weapon actions are included in the combat action, tank-hunter killer operations, as well as in the hasty defense. The only critical combat task not covered in the combat action, hasty defense, is the task involving "deliberate methodical movement with detailed observation." This task is covered, however, in the combat action, tank-hunter-killer operations. The combat action, ambush, is included as a subelement of both hasty defense and tank-hunter-killer operations.

(7) Combat Outpost. The combat outpost is a security element which denies the enemy close ground observation of the battle area and provides early warning of his advance. The combat outpost generally engages the enemy with long-range fires and avoids direct close contact whenever possible. Antitank weapons are normally positioned for mutual support to engage enemy armor at maximum range By virtue of the critical combat tasks performed, the combat action, combat outpost, is grouped under the title, retrograde operations. This action is characterized by medium-to-long-range fires and rapid withdrawal without decisive engagement. The combat action, retrograde operations, falls under the category of mobile operations, and will be discussed at length later on in this study.

(8) Roadblocks. The combat action, roadblock, is used to prevent or hinder enemy movement beyond a point or area along a road or other route of advance. The planning of a roadblock is quite similar to that used in a deliberate defense. Reference to the task/action concept table shows that all the combat tasks performed in a roadblock operation are common to the deliberate defense. Based upon this fact the roadblock is combined as a subelement of the representative combat action, deliberate defense.

Discussion and analysis of the combat actions in the static operations category reduce the number of combat actions within the category from eight to two. The two representative combat actions remaining are the deliberate defense and the hasty defense.

b. Mobile operations are:

Fire and Movement

Tank-Hunter Killer Operations

Advance to Contact

Combat in Cities

Retrograde Operations

Frontal Assault

Exploitation

River Crossing

Aerial Assault

Search and Clear

Combat Patrol

Counterattack

Counterambush

Security of a Moving Column

Breaching Operations

Collapsing Defense in Withdrawal
from LZ

Delaying Action

(1) Fire and Movement. Fire and movement begins when the maneuver element meets effective enemy opposition and can no longer advance under cover of supporting fires without taking unacceptable losses. Fire and movement within the maneuver element is characterized by the action of individuals, fire teams, and squads in the assault of an objective. Maximum aimed firepower must be used to cover the advancing elements. The combat action, fire and movement, is considered as a representative combat action.

(2) Tank-Hunter Killer Operations. This combat action is characterized by small teams trained to destroy, disorganize, and delay armored formations. Normally the teams are relatively mobile and engage their targets from close range with light antitank weapons. Since this combat action deals with special operations it is considered by itself as a representative combat action.

(3) Advance to Contact. Advance to contact is an offensive action designed to gain and maintain contact with the enemy. Consideration of this combat action indicates that it is representative of other combat actions which will be included under the title, advance to contact, as subelements.

(4) Combat in Cities. The combat action, combat in cities, is characterized by restricted observation and fields of fire as well as excellent concealment and cover for both the attacker and the defender. Movement is difficult by vehicle since streets and alleys constitute readymade fire lanes and killing zones. Direct fire weapons must be well forward in order to be effectively employed. By virtue of its wide spectrum of critical combat tasks the combat action, combat in cities, must be designated as a representative action.

(5) Retrograde Operations. A retrograde operation is any organized movement of a unit to the rear or away from the enemy. It may

be forced by the enemy or made voluntarily. A retrograde operation may be classified as a withdrawal, a delaying action, or a retirement. Good observation and fields of fire are sought to permit engaging the enemy at long ranges. Routes of withdrawal are carefully reconnoitered in order to exploit the terrain to the maximum. The combat action, retrograde operations, was selected as a representative combat action based upon the critical combat tasks which are performed.

(6) Frontal Assault. The frontal assault is normally the final assault on the objective and is characterized by a high volume of fire both aimed and suppressive in nature. Reference to the task/action concept table indicates that all critical combat tasks performed during this combat action are also performed during the combat action, fire and movement. For this reason the combat action, frontal assault, is included as a subelement of fire and movement.

(7) Exploitation. Exploitation is an offensive operation which may follow a successful penetration or envelopment. It is characterized by relatively rapid movement and mobility with the primary emphasis being placed upon keeping the enemy disorganized and in a state of retreat. Only a limited number of critical combat tasks are performed during this combat action and for this reason it will be included as a subelement of the representative combat action, fire and movement. This grouping will allow all the measurable parameters of exploitation to be evaluated.

(8) Search and Clear. The combat action, search and clear, is a special operation used as an effective measure to combat guerrilla forces. It is characterized by alert movement with rapid reaction to enemy fire, medium to short range enemy contact, and aggressive action to gain and maintain enemy contact. The critical combat tasks performed during this combat action are also included in the representative combat action, advance to contact, and allow the search and clear operation to be considered and evaluated as a subelement of this representative combat action.

(9) Combat Patrol. Combat patrols are heavily armed detachments sent out to kill or capture the enemy or to destroy his equipment, materiel, or installations. They are characterized by alert movement with rapid reaction to enemy fire, medium to shortrange enemy contact, and aggressive, violent action to destroy the enemy. Mobility and firepower are two necessary ingredients of this combat action. The critical combat tasks performed during the combat patrol are also considered during the representative combat action, advance to contact. Reference to the task/action concept table indicates that this combat action can be completely evaluated as a subelement of advance to contact.

(10) Recon Patrol. Reconnaissance patrols move to specified points or areas, gather required information through observation, and report information obtained. They will avoid enemy contact whenever possible, fighting only when necessary to accomplish the mission. Mobility and stealth are prime considerations. The critical combat tasks performed can all be properly evaluated under the representative combat action, advance to contact.

(11) Counterattack. A counterattack is a limited-objective attack designed to destroy or eject the enemy from an area of penetration and to regain lost portions of the battle area. This combat action deals with a total group reaction and is consequently difficult to measure on an individual basis. The reaction of the group is the result of considerable training and teamwork involving the same individual/crew actions found in fire and movement. This combat action can be properly evaluated as a subelement of the representative combat action, fire and movement.

(12) Counterambush. The counterambush, much like the counterattack, deals with a total group reaction and is consequently difficult to measure on an individual basis. The critical combat tasks performed can all be evaluated under the representative combat action, fire and movement.

(13) Security of a Moving Column. This combat action includes such critical combat tasks as alert movement with rapid reaction to enemy fire, medium-to-short-range enemy contact, and aggressive action to gain and maintain enemy contact. Reference to the task/action concept indicates that all the tasks considered are also covered under the representative combat action, advance to contact.

(14) Breaching Operations. The role of the antitank weapon in this combat action is to neutralize the fires of a bunker under attack, enemy forces in open emplacements around the bunker, and locations suspected of containing enemy who can hinder the advance of a maneuvering element. All the critical combat tasks performed in this combat action can be evaluated under the representative combat action, fire and movement.

(15) Collapsing Defense in Withdrawal from an LZ. This combat action is a special operation brought about by the introduction of the helicopter as a primary source of mobility in combat. It deals primarily with a progressively decreasing perimeter defense designed to protect the operations on the LZ itself. The critical combat tasks performed are varied and most closely resemble the tasks required in

retrograde operations. The task/action concept table shows that all the critical combat tasks can be properly evaluated under the representative combat action, retrograde operations.

(16) Delaying Action. The delaying action is an operation in which a force under pressure trades space for time while inflicting maximum punishment on the enemy without becoming decisively engaged in combat. During the conduct of the operation the delaying force maintains contact with the enemy. It delays to the maximum between, as well as on, successive positions. It takes advantage of all obstacles and employs maximum fires at long ranges. Mobility and long-range aimed fire are two important characteristics of this combat action. All the critical combat tasks performed during this action are included in the representative combat action, retrograde operations.

c. The 25 combat actions initially considered have now been reduced to 7. Each critical combat task considered in the 25 combat actions is considered in the 7 representative combat actions. This summary is shown in Figure D-3.

COMBAT ACTIONS	REPRESENTATIVE COMBAT ACTIONS
STATIC OPERATIONS	
Deliberate Defense	DELIBERATE DEFENSE
Fire and Maneuver	
Roadblocks	
Hasty Defense	HASTY DEFENSE
Area or Position Security	
Reorganization and Consolidation	
Ambush	
Combat Outpost	
MOBILE OPERATIONS	
Retrograde Operations	RETROGRADE OPERATIONS
Collapsing Defense in Withdrawal from LZ	
Delaying Action	
Fire and Movement	FIRE AND MOVEMENT
Exploitation	
Breaching Operations	
Counterattack	
Counterambush	
Frontal Assault	
Tank-Hunter Killer Operations	TANK-HUNTER KILLER OPERATIONS
Combat in Cities	COMBAT IN CITIES
Advance to Contact	ADVANCE TO CONTACT
Security of a Moving Column	
Search and Clear	
Combat Patrol	
Recon Patrol	
River Crossing	(Form of mobility followed by: Frontal Assault, Fire and Movement, Advance to Contact, or Hasty Defense.)

Figure D-3

ANNEX E

MEASURES OF EFFECTIVENESS

1. GENERAL

Consideration of the categories of effectiveness, such as accuracy, responsiveness, reliability, sustainability, etc., revealed that these categories must be defined in terms of measurable parameters which meaningfully relate to a combat situation. Once defined, these parameters were further studied and developed into measures of effectiveness (MOE) in order to measure effectively and then to evaluate properly small differences between competing weapons systems (see Figure E-1). These MOE evolved in four ways:

a. Measures that must be collected in order to compile other data, such as number of hits. By itself, this measurement has little meaning, but when combined with number of rounds fired a hit probability can be obtained.

b. Measures that stand alone, such as time to first round. This measurement of effectiveness stands alone as a measure of the amount of time it takes to fire a round once a target is identified.

c. Measures that are combinations of two or more measures. For example, engagement hit probability is a consideration:

$$\frac{\text{Number of Target Hits}}{\text{Number of Targets Engaged}} = \text{Engagement Hit Probability}$$

d. Measures specifically designed to evaluate special situations such as the probability of a first-round hit with an antitank weapon in a tank-hunter-killer operation.

$$\frac{\text{Number of First Round Target Hits}}{\text{Number of Target Engagements}} = \text{Probability of First Round Hit}$$

These measures of effectiveness are related to the original combat actions required of an AT weapon system as shown in Figure E-2. In effect the actions required were delineated and reduced to a set of seven representative actions. Those seven actions were sub-divided into specific sets of tasks. The tasks were described qualitatively by sets of measurable parameters.

ACCURACY

Number of hits
Distribution of near misses
Engagement/hit probability
Probability of first round hit

RESPONSIVENESS

Time to first round
Time to reload
Time to first hit
Time to prepare to fire
Time between rounds
Time to shift fires
Time between hits
Sight manipulation time

SUSTAINABILITY

Hits per pound with respect to basic load

RELIABILITY

Time to clear malfunctions
Number of rounds between malfunctions

PORTABILITY AND COMPATIBILITY

Ease of handling (hot/cold) (subjective)
Movement time
Preparation of position and emplacement of barriers (subjective)
Compatibility and ancillary equipment (subjective)
Time to change positions and/or cross obstacles
Time to dismount/remount weapon from/on vehicle mount

SIGNATURE EFFECTS

Sound level recording (blast)
Obscuration (smoke and haze)
Troop safety area required
Visual light emission (flash)
Infrared signature

DURABILITY

Ability to operate after extended movement and/or handling (subjective)
Number of failures as a function of operational environment

STABILITY

Mount stability (wet/dry) (photographic measuring techniques)
Stability after changing positions (wet/dry) (subjective)

MEASURES OF EFFECTIVENESS

Figure E-1

CATEGORY	MEASURES OF EFFECTIVENESS / REPRESENTATIVE COMBAT ACTIONS	DELIBERATE DEFENSE	HASTY DEFENSE	RETROGRADE OPERATIONS	FIRE AND MOVEMENT	TANK HUNTER-KILLER OPERATIONS	COMBAT IN CITIES	ADVANCE TO CONTACT
ACCURACY	Number of hits	X	X	X	X	X	X	X
	Distribution of near misses	X	X	X	X	X	X	X
	Engagement/hit probability	X	X	X	X	X	X	X
	Probability of first round hit	X	X	X	X	X	X	X
RESPONSIVENESS	Time to first round	X	X	X	X	X	X	X
	Time to reload	X	X	X	X	X	X	X
	Time to first hit	X	X	X	X	X	X	X
	Time to prepare to fire	X	X	X	X	X	X	X
	Time between rounds	X	X	X	X	X	X	X
	Time to shift fire	X	X	X	X	X	X	X
	Time between hits	X	X	X	X	X	X	X
	Sight manipulation time	X	X	X	X	X	X	X
SUSTAINABILITY	Hits per round with respect to basic load	X	X	X	X	X	X	X
RELIABILITY	Time to clear malfunctions	X	X	X	X	X	X	X
	Number of rounds between malfunctions	X	X	X	X	X	X	X
PORTABILITY AND COMPATIBILITY	Ease of handling (hot/cold)	X	X	X	X	X	X	X
	Movement time	X	X	X	X	X	X	X
	Preparation of position and emplacement of barriers	X	X				X	
	Compatibility with ancillary equipment	X	X	X	X	X	X	X
	Maneuverability when changing positions and/or crossing obstacles	X	X	X	X	X	X	X
	Time to dismount/remount weapon from/on vehicle mount		X	X			X	
	Crew training requirements							
	Ability to engage a moving target	X	X	X	X	[illegible]	X	X
SIGNATURE EFFECTS	Sound level recording (blast)	X	X	X	X	X	X	X
	Obscuration (smoke and haze)	X	X	X	X	X	X	X
	Troop safety area required	X	X	X	X	X	X	X
	Visual light emission (flash)	X	X	X	X	X	X	X
	IR signature	X	X	X	X	X	X	X
DURABILITY	Ability to operate properly after extended movement and/or handling	X	X	X	X	X	X	X
	Amount of breakage as a function of operational environment	X	X	X	X	X	X	X
STABILITY	Mount stability (wet/dry)	X	X	X	X	X	X	X
	Stability after changing positions (wet/dry)	X	X	X	X	X	X	X

Figure E-2

These measures are then related back to the seven combat actions. In essence, the necessary actions required by a combat AT weapon system can be quantified by specific sets of measures. The measures of effectiveness are discussed below by category of effectiveness.

2. ACCURACY

There are five measures considered in the category of accuracy.

a. Number of Hits. This information can be obtained in two ways. The test officer may physically go downrange and count the number of holes in the target, or he may rely on collecting the data electronically. The electronic collection of data is perferable since it would allow the exercise to be conducted in a continuous manner with no halts for data collection. Realism would thus be enhanced and the "combat atmosphere" retained. The information obtained is used to compile other data, e.g., when combined with numbers of rounds fired, hit probability may be derived.

b. Distribution of Near Misses. The high cost of ammunition for antitank weapons makes this measurement a particularly desirable one. An accurate method of measuring the location of near misses would be invaluable since it might indicate that the weapons system is, in fact, accurate but that the sight is misaligned or even more important, improperly designed. This added data would greatly assist the test officer in his analysis of weapon performance and would reduce the risk of rejecting an acceptable weapons system.

c. Engagement/Hit Probability.

(1) This MOE is a hybrid measure not directly observed but computed from the number of hits observed divided by the number of rounds fired under a given set of conditions. Hit probabilities only reflect combat performance to the extent that the test environment reflects combat environment. Hit probabilities obtained on a known distance target range may indicate large differences between competing weapons systems but do not necessarily indicate performance that could be expected under combat conditions.

(2) To be a meaningful measure, much care must be taken in test design and conduct so that observed results can be applied to actual combat.

(3) Several types of hit probabilities should be measured under the simulated combat conditions of the test facilities. These would include probability of first and subsequent round hits. Hit probabilities are used to compare weapon performance on the test facilities as a function of range, angle of fire, type of target, time of exposure, weapon, learning, training or any combination of these variables. To the extent that test conditions relate to combat, this

measure is an evaluation of the total performance of the individual/crew weapon system in combat. The MOE can be referred to as a gross measure, not relating to a specific action such as sight alignment, but to the sum of the actions of the individual/crew as they use the weapon.

(4) In general, engagement hit probabilities will indicate weapon differences. However, other measures are necessary to isolate discrete causes of weapon differences.

d. Probability of First Round Hit. This measure is particularly important with antitank weapons since there is rarely a chance to fire a second round at an armored target. In antitank warfare a great deal of importance is placed upon "first round kill" capability. It is conceivable that this measure could be a key factor in the selection of competing weapons systems. In the last few years a great deal of development has gone into trying to develop antitank rounds which could be guided in flight to increase further the probability of a first round hit. This probability is easily computed provided other physical measurements have been taken.

$$\frac{\text{Number of First Round Target Hits}}{\text{Number of Target Engagements}} = \text{Probability of First Round Hit}$$

3. RESPONSIVENESS

This is basically a time-related measurement which gives an indication of how rapidly a weapon may be made to perform its assigned function. Under extreme conditions a man might be required to operate a crew-served weapon by himself. Responsiveness in this case would be a measure of how easily the weapon can be controlled and made to operate properly. The eight measures of effectiveness considered in the category of responsiveness are:

a. Time to First Round. This MOE provides data on the length of time it takes the crew (or individual firer, depending upon the weapon) from target exposure to (1) identify the target, (2) assume a firing position and perform the necessary crew drill, (3) acquire the target in the weapon's sighting system, and (4) fire the first round. The importance of this measure varies from combat action to combat action. As in several of the combat actions, particularly those in which alert movement is required, a quick response to surprise fire or targets of opportunity is essential.

b. Time to Reload. This measurement is primarily based upon weapon and round design. Crew familiarity with the weapon system will serve to reduce this time and consequently the crews for two

competing weapons systems must display equal levels of proficiency with their weapons systems. The time to reload becomes particularly important as a measurement when multiple targets are engaged by the same weapons system.

c. Time to First Hit. Ideally, this measurement should be the same as that described in subparagraph a above, with the time of flight of the projectile added. The value of this MOE is relatively high since a hit must be achieved for mission accomplishment. The more time required to achieve a first hit only serves to reduce the chances of successful mission accomplishment. Acquisition time is considered relatively constant whether the firer achieves a hit or not; therefore, the MOE "time to first round" is actually the time required to aim and achieve a hit. In a 2-weapon comparison the weapon requiring the least amount of time and rounds between first round and first hit could gain a decided advantage.

d. Time to Prepare to Fire. This MOE provides information on some of the human engineering aspects of a weapon system. Time to prepare to fire actually measures crew drill time with reference to the weapons system being examined. Such items as poor tripod or mount construction, awkward sighting mechanisms, lack of carrying or handling brackets, and extreme system weight could be detected through the use of this MOE.

e. Time Between Rounds. This MOE is actually a combination of the time required to reload with the time needed to acquire the target in the sights and to manipulate the firing mechanism. The measurement could be used to isolate differences between competing weapon sighting and firing devices. An extremely complex and sophisticated system which requires a great deal of operator training and expertise might jeopardize its changes of acceptance through the use of this MOE.

f. Time to Shift Fires. This MOE is a combination measurement that provides data on the time required to shift fire to another target after achieving a target hit and to acquire the new target. Position change time (if required), sight manipulation time (if required), traversing and elevation mechanism time (if required), reloading, sight alignment, and firing are all incorporated into this measurement. With the antitank weapon system and its method of employment, this measurement might well include the time required to move to an alternate or supplementary firing position and consequently would involve measures of portability and maneuverability

g. Time Between Hits. This measurement can be obtained for two different situations. The time required between hits on the same target would be one situation while the time required to shift fire and obtain a hit on a new target (shift and acquisition time) would be the other situation. This MOE can also be construed as a measure of stability of the weapon system since more time will be required to reload, realign, and fire an unstable system than one that needs only minor readjustment to achieve a second hit on the same target.

h. Sight Manipulation Time. This MOE provides data on the amount of time required to mount the sight on the weapon (if applicable) or to set up the sighting mechanism (if remote from the weapon) and perform all adjustments necessary to enable the weapon system to engage and destroy a target.

i. All of the above measures (under the category of responsiveness) are compiled and can be computed as separate functions of range, target type, firing angle, position of firer, and type of mount (these separate functions should be varied as much as p ssible during weapon testing). For example:

(1) Range: There will be a difference in time for all of the MOE in that the category of responsiveness based on range--varying from the minimum arming distance for the projectile out to the maximum effective range--will directly affect the time required to align the sights and the target.

(2) Firing angle: The firing angle may be expressed in degrees and direction such as 90° left and 45° right; in addition, vertical angles must be considered (such as 5° above or below the horizontal). Both of these angles must be taken into consideration when collecting and computing data on the MOE.

(3) Target type: The various types and sizes of targets found on the battlefield (tanks, bunkers, large groups of men) and their ability to move at varying speeds (man and vehicles) must be taken into consideration when collecing and computing data on the MOE.

(4) Position of crew/weapon: This MOE considers such factors as: supported or unsupported firing positions, positions offering clear fields of fire as opposed to those which offer many obstacles and terrain which permits stable positioning of the weapon as opposed to rocky or muddy terrain which might cause difficulty in mounting the weapon in its proper firing configuration. All of these factors and many others within this category must be considered when computing or recording data on the MOE.

(5) Type of Mount: This would take into consideration such different mounting systems as man mounted or held, tripod or bipod mounted, and vehicle mounted. Again, as with the previous categories, consideration must be taken when collecting and computing data on the MOE.

4. SUSTAINABILITY.

a. This category of effectiveness is indicative of the life of a weapon in a combat environment with respect to the basic load of ammunition for the weapon. All measures of effectiveness (total rounds, number of rounds to first hit, number of rounds between hits, and number of rounds fired per engagement) are contributive. Sustainability, therefore, is best described as hits per pound with respect to the basic load of the weapon system. This measure will allow us to compute the number of engagements per basic load if each hit were considered a kill).

b. Sustainability relates the combat effectiveness of the system to its basic load and attempts to anticipate the amount of time or the number of engagements the system can expect to remain in a combat action. Basic loads are often augmented or changed by local directives (taking into consideration the threat posed by enemy armor). A weapon with a relatively high hit probability which fires an excessively heavy round might compare unfavorably with another weapon having a lower hit probability which fires a much lighter round. The amount of trade-off between hit probability and ammunition weight would have to be a decision based upon situation and anticipated threats. This MOE should definitely be looked into and evaluated during testing of a new or modified antitank weapons system.

5. RELIABILITY

The two measurements of effectiveness considered in the category of reliability are:

a. Time to Clear Malfunctions. A malfunction is a failure of the weapons system to function satisfactorily. Improper operation of the weapon by a crew member is not considered a malfunction. The importance of this MOE is obvious since a malfunction effectively neutralizes the weapon's usefulness.

b. Number of Rounds Between Malfunctions. This MOE is a definite indication of the true reliability of the weapons system. The MOE must be sequentially counted by round fired, from the initial

round fired throughout completion of all firing exercises. The data obtained are necessary to compute the probability that a round will be fired when the trigger is pulled.

6. PORTABILITY AND COMPATIBILITY

a. The measurements of effectiveness considered in the category of portability and compatibility vary from combat action to combat action, are difficult to measure accurately, and cannot generally be measured with instrumentation. The entire category is considered to be a human factors judgment area and will be considered in each combat action to detect anything about the weapon which may hinder the individual/crew weapon performance. As an example, the ease of handling a weapon system might be excellent while the weapon is cold, but once it is heated by sustained fire the ease of handling might suddenly become extremely poor.

b. Performance measures include but are not limited to the following:

(1) Ease of handling (hot/cold). This is a comparison measurement between ease of handling before the weapon has been fired (or before it has been fired sufficiently to significantly raise weapon temperature) and after the weapon has been heated by sustained fire.

(2) Movement time. This measurement evaluates speed of movement with the weapon in various combat situations.

(3) Preparation of position and emplacement of barriers. This measurement evaluates speed of position preparation and barrier emplacement. Reaction time of the individual/crew/weapon combination to enemy activity during the performance of these combat tasks is carefully analyzed in order to detect differences between competing weapons systems.

(4) Compatibility with ancillary equipment. This is a measurement of how well the weapon system and its various components complement each other.

(5) Maneuverability when changing positions and/or crossing obstacles. This measurement evaluates the speed and ease in which the individual/crew/weapon combination is able to change position or negotiate a given obstacle. The data obtained are useful in a 2-weapon comparison.

(6) Time to dismount/remount weapon from/on vehicle mount. This measurement evaluates the speed and ease with which the individual/crew can dismount or remount a vehicle-mounted weapons system. The data compiled can be used for a 2-weapon comparison.

(7) Crew training requirements. The time and effort, in terms of man-hours, material, and financial assets, required to train a crew or individual on a specific weapons system are factors which must be considered. This measurement may be used in the comparison of two or more weapons systems.

(8) Ability to engage a moving target. This measurement is an indication of the weapon's traversing and elevating capability with respect to the individual/crew operating the system..

7. SIGNATURE EFFECTS.

The five measurements considered in the category of signature effects are:

a. Sound level recording (blast). This signature effect will be measured and evaluated in two parameters: (1) to determine if there is any danger to the firer's and adjacent firers' ears; and (2) to determine if the sound of the weapon will readily identify its location on the battlefield.

b. Obscuration (smoke and haze). This signature effect will be measured in two manners: (1) to determine if the muzzle blast kicked dirt and dust into the air in sufficient amounts to interfere with the sighting and aiming process; (2) to determine if this same dirt and dust will disclose the firer's position.

c. Visual light emission (flash). This signature effect will be measured. The muzzle flash is the most noticeable signature effect and as such tends to disclose the firer's position. Flash can be measured in such terms as size, duration, and intensity during day and night conditions.

d. Troop safety area required. Different weapons systems require a variety of troop safety considerations with respect to back blast or muzzle blast. A measurement of the safety area required can be used in a 2-weapon comparison.

e. Infrared signature. This is a measure of how easily the weapon can be detected by infrared devices. This measurement draws its importance from the fact that infrared devices are becoming more and more common on the battlefield. The data obtained by measuring acquisition ease are useful in a 2-weapon comparison.

8. DURABILITY

There are two measurements considered in this category.

a. Ability to operate properly after extended movement and/or handling. This measurement is useful in determining the relative

durability of two or more weapons systems. It is assumed that the extended movement and/or handling will be one in a combat-like environment and will subject the weapon to stresses normally experienced in such an environment.

b. Amount of breakage as a function of operational environment (relative to a standard or competing system). This measurement, much like the one above, is designed to detect durability failures and to apply this measurement in a 2-weapon comparison. Breakage which renders the weapon inoperative should be noted and distinguished from breakage which does not affect weapon operation.

9. STABILITY

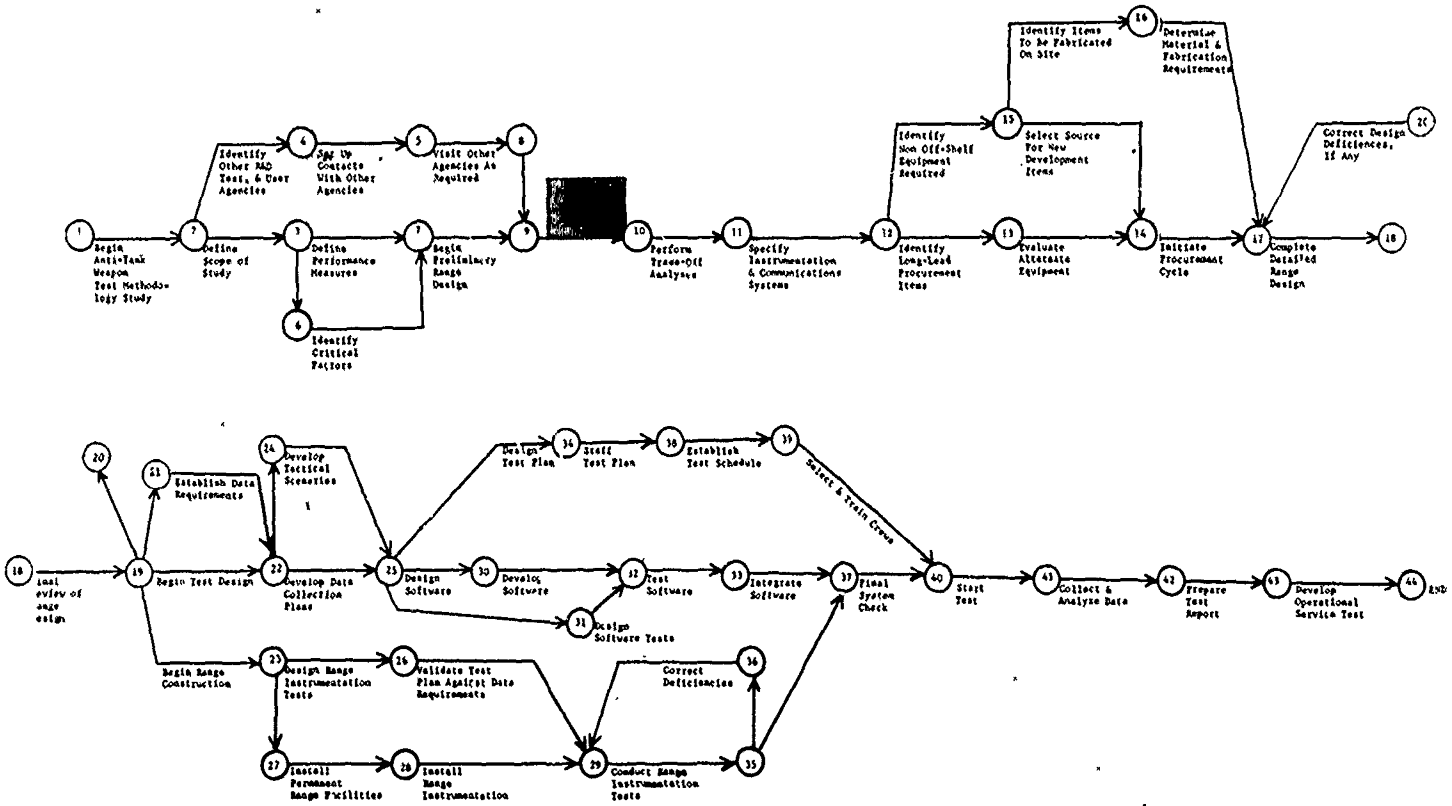
a. The stability of the gun platform is a vital consideration. Failure during firing could result in mission failure as well as increase the risks taken by the individual/crew operating the weapons system.

b. The tests of bipod, tripod, and vehicle-mount stability can be performed in conjunction with other firing exercises. The mounts should be tested on various types of terrain: muddy, wet, solid, high grass, dry grass, sand bags, hills, etc., as well as in the various combat actions. The mounts will be observed in each varying situation to detect anything about the weapon which may hinder the individual/crew/weapon combination in the performance of its mission.

ANNEX F

PERT ANALYSIS

The following page presents a summary PERT analysis of the antitank weapons test methodology study leading to the establishment of an antitank weapons test range, the conduct of weapons tests under quasi-combat conditions, the preparation of a final report, and the development of operational service tests.



PERT ANALYSIS OF ANTITANK METHODOLOGY STUDY

Figure F-1

ANNEX G

REFERENCES

1. Infantry Antitank Weapon Methodology Review, USAIB, Capt. Cunningham, July 1970.

2. Project Analysis, Antitank Weapons Test Range, Litton Systems, Inc., Mellonics Division, DA EA 18-68-C-0004, 9 January 1970.

3. Missile, Guided, Antitank, MTP 5-3-057, USATECOM Commodity Service Test Procedure, November 1969.

4. Anti-Tank Target Hit Skin, Technical Memorandum, Litton Systems, Inc., Mellonics Division, DA EA 18-68-C-0004, 9 June 1969.

5. Launcher, Rocket, Individual Weapon, MTP 3-3-040, USATECOM Commodity Service Test Procedure, January 1969.

6. Project Pinpoint, Disclosure of Anti-Tank Weapons to Over-Watching Tanks, Technical Memorandum ORO-T- 362, Operations Research Office, Johns Hopkins University, Bethesda, Md. (Unclassified).

7. An Analysis of Factors Which Influence Tank and Anti-Tank Engagement Ranges - CORG., February 1962, AD 371 815.

8. Anti-Tank Guided Weapons, An Initial Estimate of Performance Under Operational Conditions, Royal Armaments Research and Development Establishment (B) 42/63, AD 340 343.

9. TM 9-100-205-12, Operator and Organizational Maintenance Manual, 106MM Recoilless Rifle, M40A1 with Cal. .50 Spotting Gun M8C on Mount M79 or M92 with Tripod M27, and 106MM Recoilless Rifle M40A1C used on Multiple 106MM Ft. SP. Rifle M50; Mar. 1959, with Change 2., Oct. 1965 Hq., D.A., Washington, D. C. (Unclassified).

10. Military Small Group Performance Under Isolation and Stress, Critical Review, U.S. Department of Commerce, June 1962 (U66-1231).

11. Stress, Institute for Defense Analysis, R and E Support Division, Dr. Joseph Weitz, April 1956.

APPENDIX IV

TECHNICAL MEMORANDUM
ANTITANK TARGET HIT SKIN

TECHNICAL MEMORANDUM

FOR

UNITED STATES ARMY INFANTRY BOARD

Contract No. DAEA 18-68-C-Q004

ANTI-TANK TARGET HIT SKIN

(Electronic Scoring Material for Anti-Tank Ammunition)

Test Date:

9 June 1969

BACKGROUND

An attempt to develop or procure a hit sensitive scoring material for tank type targets was undertaken by the Combat Conditions Test Division of USAIB. Valid service testing of anti-tank weapons requires reliable target instrumentation and as near combat conditions as relistically possible. Consequently, any suitable scoring material must have two basic characteristics: it must be rigid enough to duplicate tank and APC silhouettes and it must reliably score projectiles of all calibers that could be used as anti-armor weapons.

Initially, the two layer aluminum foil/latex foam hit skin, having proven very successful for scoring small arms, was testd against larger rounds and found to be inadequate. The larger rounds tended to tear out several pieces of material reducing target life drastically. As stronger backing material was added to reduce this effect and to provide additional support for larger silhouettes, the tendency to detonate high explosive rounds increased. These characteristics made it seem unlikely that this target material could be used in anti-tank targets.

A manufacturer who made an aerial tow target for the US Air Force was contacted. The Board received two samples of the material used in the aerial targets for testing. The material is a resin impregnated, honeycomb paper material which is very rigid and light. The two characteristics of low puncture strength and high bending strength are fulfilled. The material can be used to duplicate any armor silhouette without support backing material thus increasing the materials compatability with high explosive ammunition.

DESCRIPTION OF MATERIAL

The material is a 1¼-inch thick paper "honey comb" with a 3/8-inch call size. The paper (kraft paper) is 20% impregnated with phenolic resin (this makes the structure much more rigid), and it has paper strips in-between the ripple strips, so that the material has directional (grain) strength similar to a plain piece of wood.

The honey comb is then covered on both sides with cheese-cloth "soaked in epoxy resin" and an outside covering of .005-inch thich of aluminum foil.

The test samples are wing portions of the aerial tow target. They are, as shown in Figure 1, 4-feet wide and 3-feet high. All edges, except for the right hand vertical, are filled with 1¼ X 2-inch wood support. The right hand vertical edge consist of a 2 X 4 structual member.

ELECTRONIC INSTRUMENTATION

The foil was connected to a tectronics $454 sotrage oscilliscope (with a Hewlet-Packard oscilliscope camera) by RG58 Co-AX cable. A 50 ohm, ¼-watt resistor was placed, as a loading resistor, at the target, across the foil.

At the oscilliscope, a resistive input network was used; the power was supplied by a 6-volt dry cell battery.

The electronic resistive test network is shown in Figure 2. (Equivalent Circuit Figure 2a).

The input triggering of the scope was set to trigger on a D. C. level change.

Figure 1

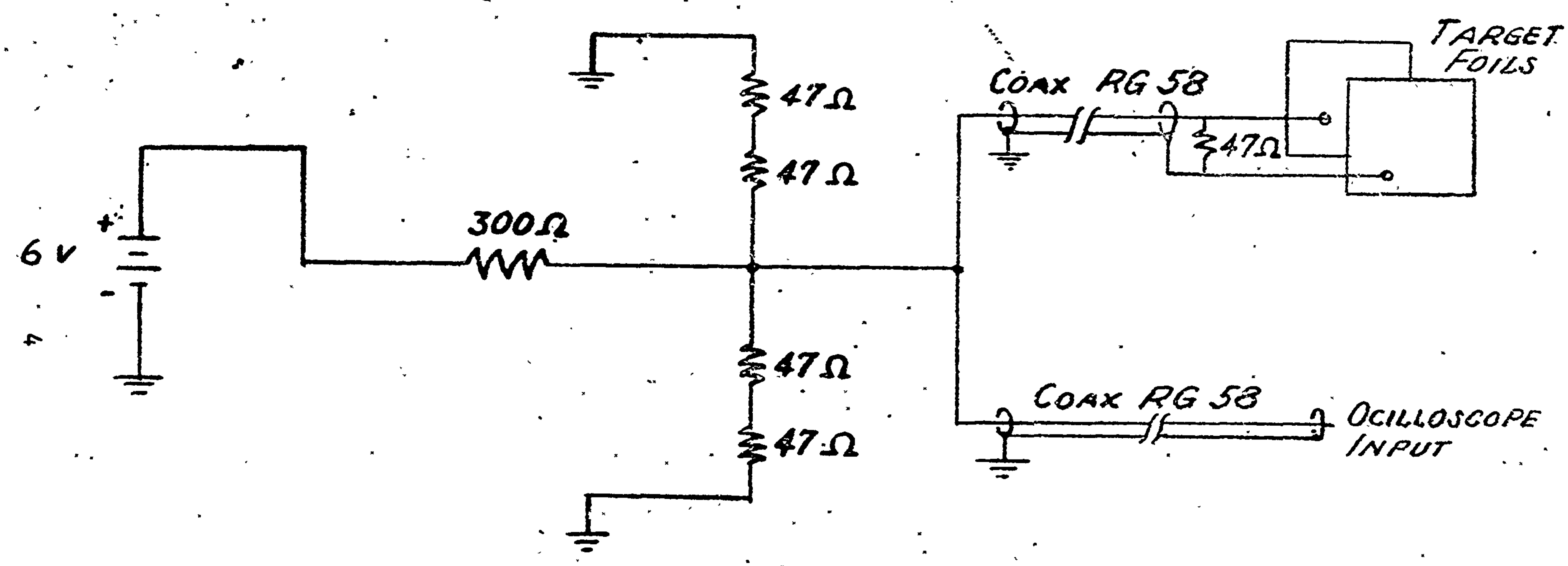


Figure 2
Schematic of Circuit Used

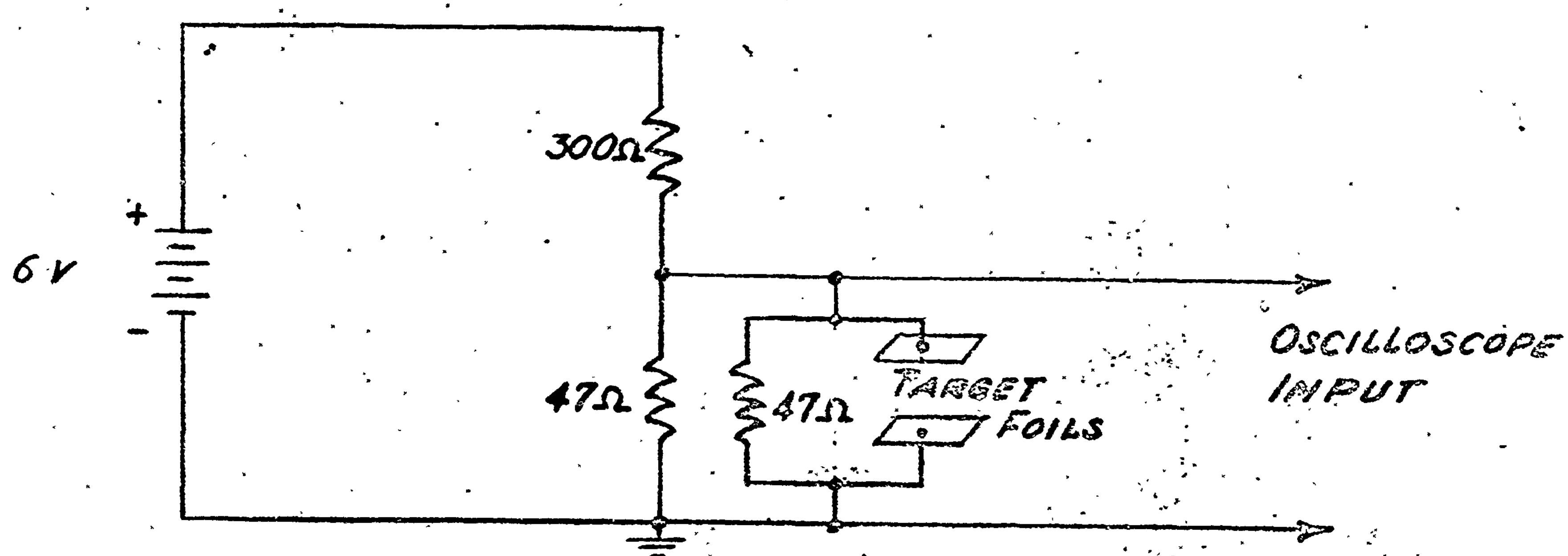


Figure 2 A
Equivalent Circuit

TEST METHODOLOGY

The first target was set up at approximately 500 yards from the firing point; the second target was set up at 100 yards.

The weapon used was 106-mm recoilless rifle with spotting gun. This weapon was a jeep mounted unit.

Several rounds of 50 Cal. were fired both as a sighting in of the "106," and as an electronic check of the hit sensitive material and the electronic circuit.

Following the 50 Cal. spotting rounds, the "106" was fired; it was fired twice at each target.

RESULTS OF TEST

Targe #1, Long Range

The first 50 Cal. recorded at 50 μ sec/cm, and .05 volts/cm (vertical) shows a pulse of approximately 20 μ sec durration and .05 volts pulse height; this is Figure 3.

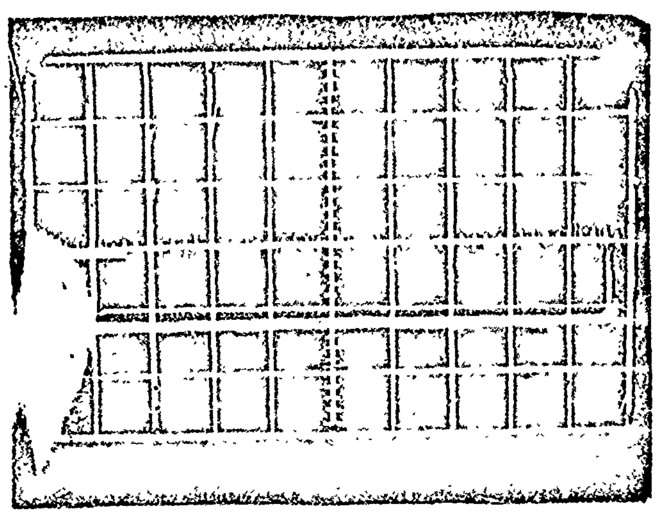


Figure 3

The second 50 Cal. spotting round registered approximately a 20 μ pulse width and a .08 volts pulse height. The scope setting was: Sweep 10 μ sec/cm, deflection .05 volts/cm. The trace recorded is shown in Figure 4.

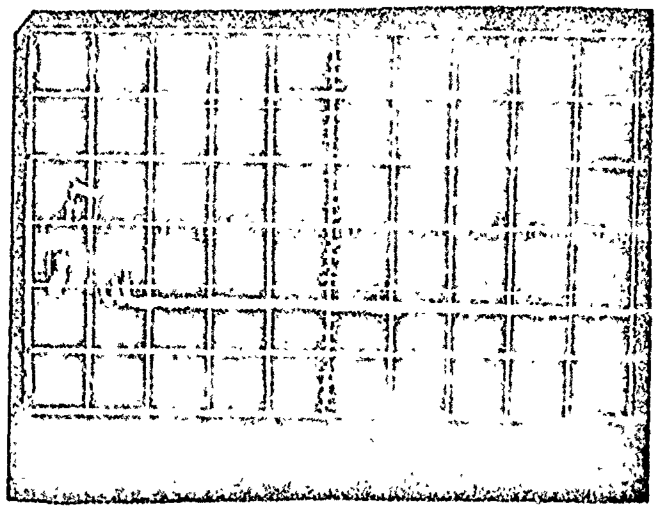


Figure 4

The first 106 round was above the target and off to the left. The ammunition used was a high explosive (H.E.) type; detonation was approximately sixty feet behind the target on the ground. (The target was not damaged). The second 106 round hit the 2 X 4 structural member of the target. Structural members are not necessary to simulate tank type targets. The material received for testing was part of a dart type aerial tow target and was made with structural members. These were not removed for the test. Detonation occurred at the target, and the target was destroyed. Figure 5 shows the oscilliscope trace resulting from the hit. The sweep triggered, thus a "short" (contact) was made. The intermittent contacts may be the foil shorting out as it tears apart. Figures 1 and 6 show before and after pictures of the test target. The fragments, Figure 6, indicate that the wood frame was hit in its lower right-hand corner.

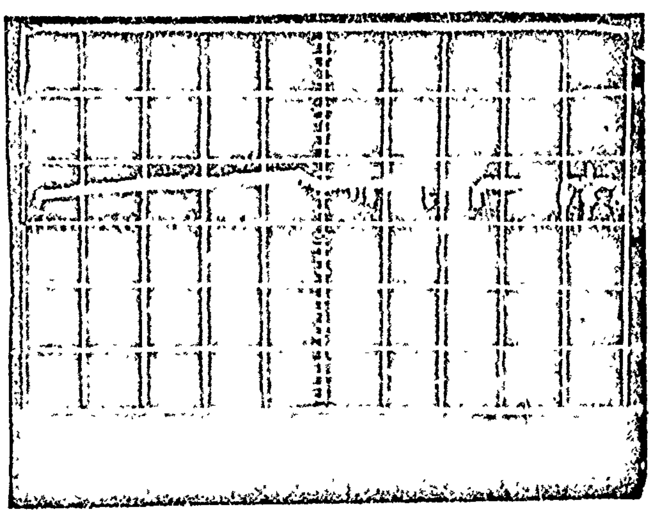


Figure 5

Figure 6

Target # 2, Short Range.

Three 50 Cal. spotting rounds were fired at the second target, Figure 7. Figures 8 and 9 show the front of the target; Figure 9 is a close-up of the round entrance area. The top hole is round #1, the bottom hole, through the supporting wood frame, is round #2, and the middle hole is round #3. Figure 10 is of the back of the target, and it shows the 50 Cal. exit holes. (The large hole above the 50 Cal. holes is a result of target #1 shell detonation).

Figure 7

Figure 8

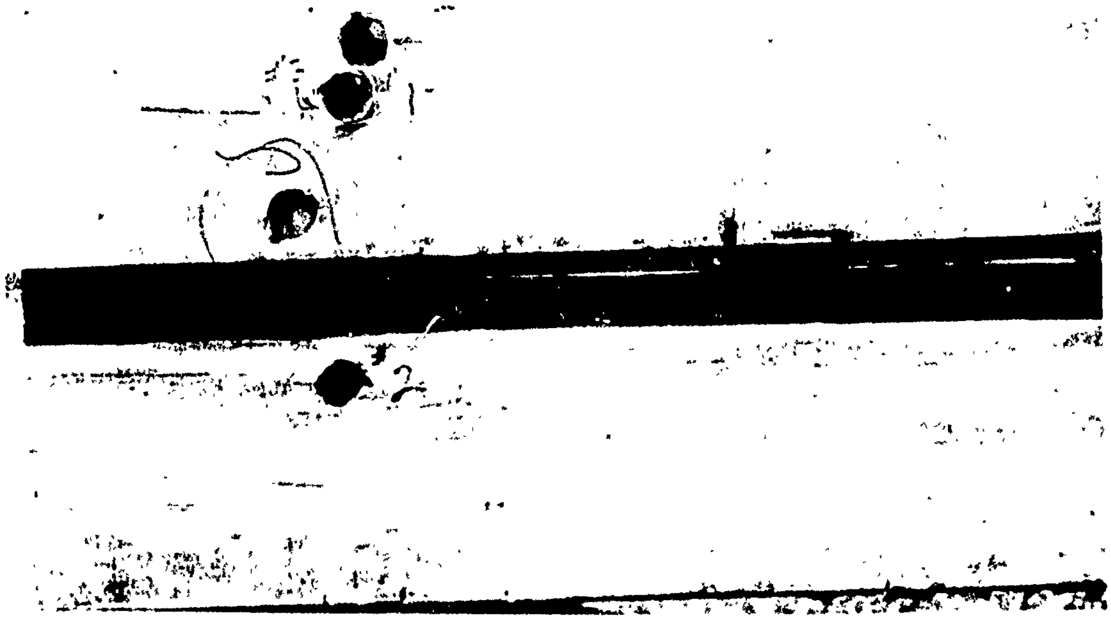


Figure 9

Figure 10

Due to detonation of target #1, the input load of 50 OHMs was not present for the tests on target #2.

Figure 11 shows the oscilliscope traces from spotting round #1. The sweep was set at 10 μ sec/cm, and vertical deflection at 0.1 volts/cm. The output pulse, in Figure 11, is 50 μ sec. in duration, and the pulse height is 0.3 volts. The breaks in the center of the pulse indicate intermittent foil contact.

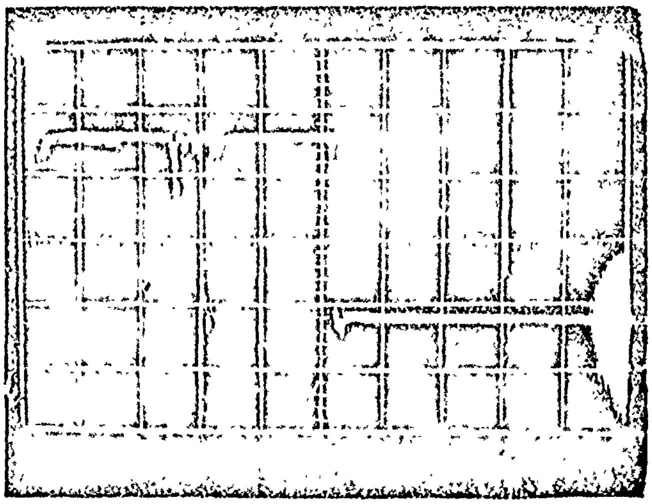


Figure 11

Round #2, was through the wood and produced no pulse.

Round #3 produced a pulse, and it is shown in Figure 12. The scope was set the same as for round #1. The recorded pulse, Figure 12, is 70 μ sec. in duration, and has a pulse height of 0.3 volts.

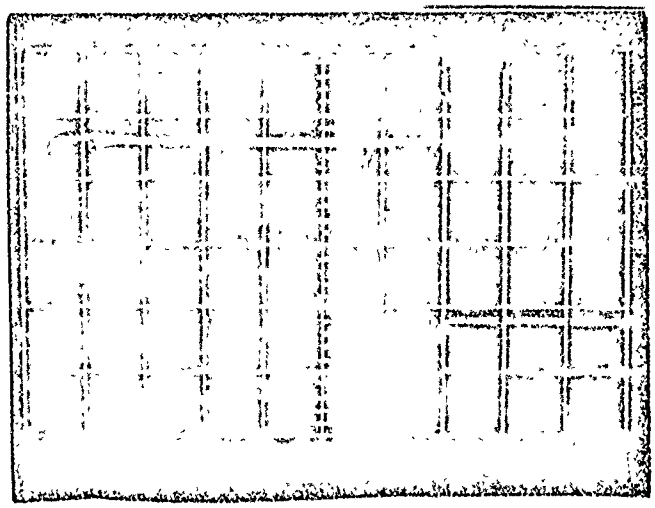


Figure 12

The first 106 round was low, and to the right of the center of the target, Figure 13 (and very near the wood frame). The second 106 round was nearly centered on the target. The target front is Figure 14, this shows the 106 round entrance holes. (NOTE: The target was angled back about 10^{o} degrees to the line of fire. The fold back of the upper portions of the foil is the result of this angle. The six slices around the hole are the result of the stablization fins on the round. Notice how the fins cut out the wood frame section below round #1). Figure 15 shows the 106 round exit holes in target.

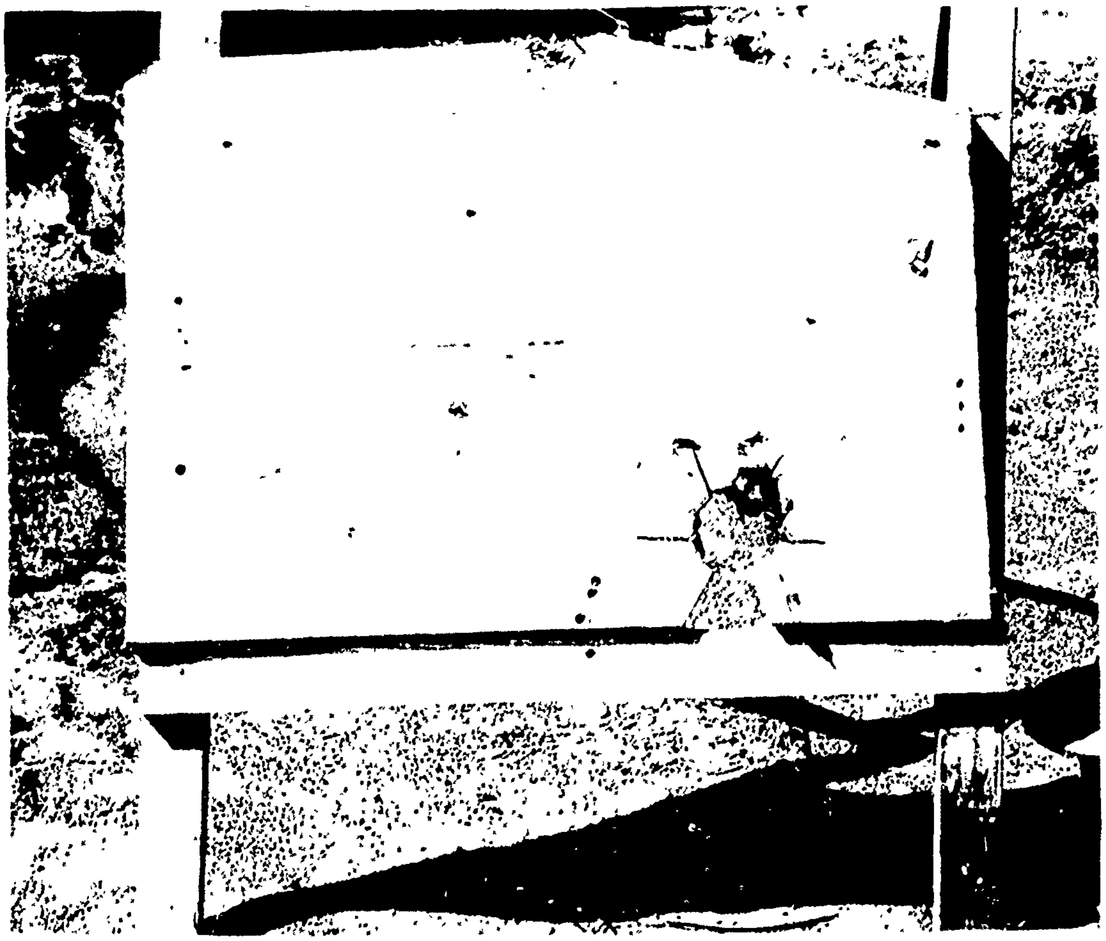


Figure 13

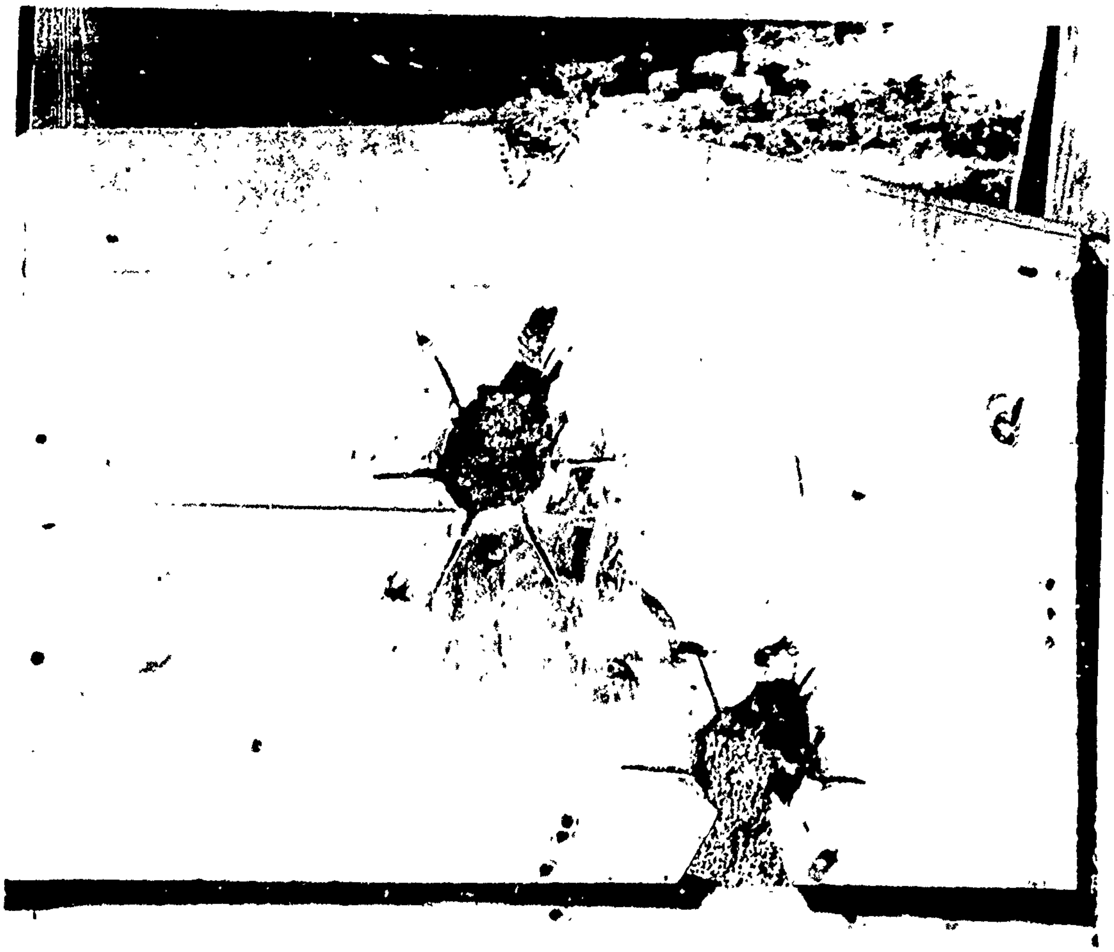


Figure 14

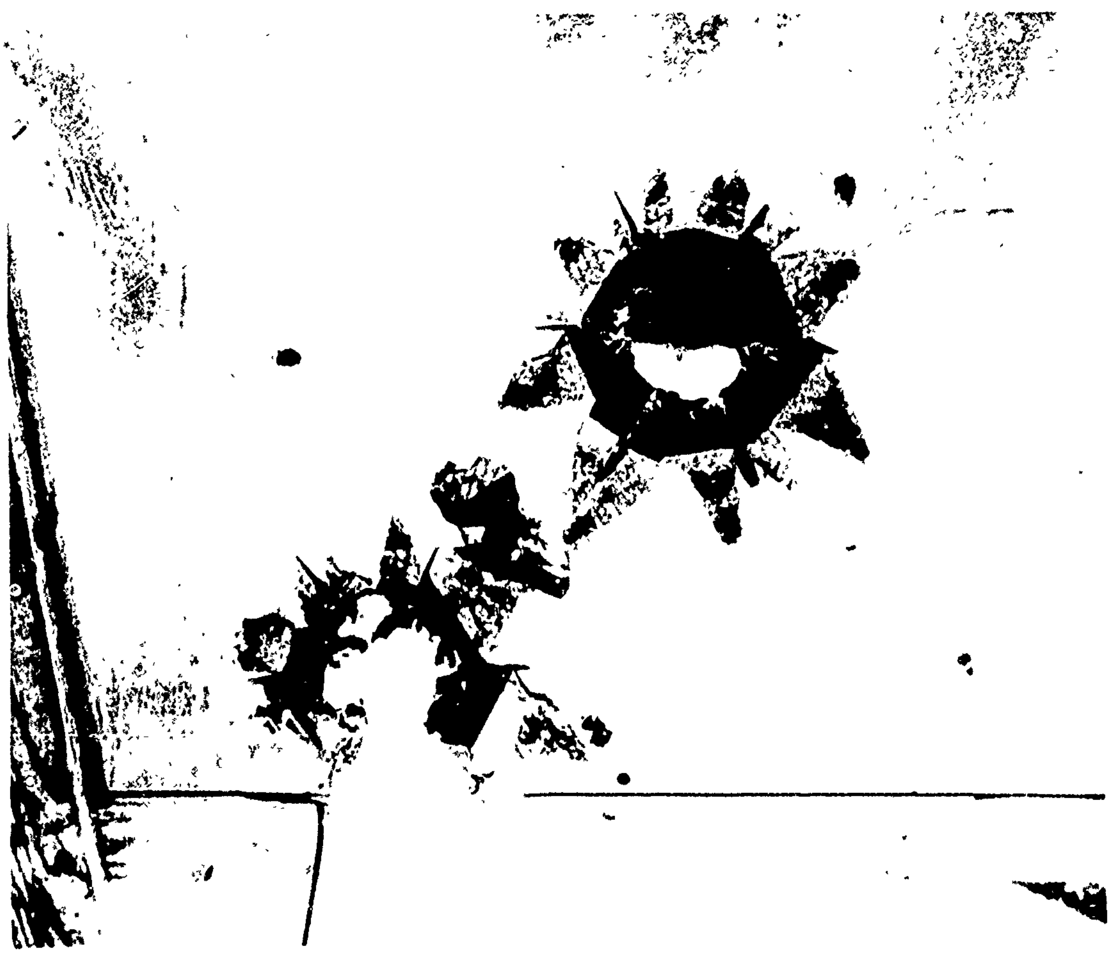


Figure 15

The first 106 round produced no pulse output due to a disconnection of the data wire at the target; the failure was caused by the preceding round, Figure 16.

Figure 16

The second 106 round produced the pulse shown in Figure 17. The sweep was set at 0.1 millisec/cm, and the deflection at .1 volts/cm (estimated?).

The pulse output has a duration of 0.05 millisec. (50 m sec.), and a pulse height greater than 0.4 volts.

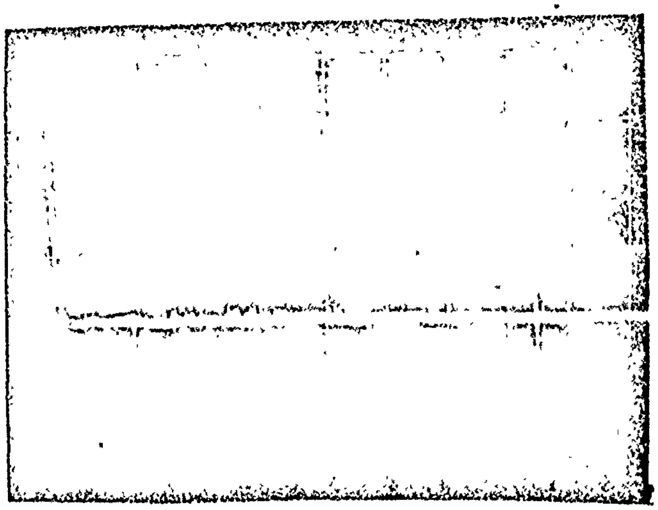


Figure 17

CONCLUSIONS

1. The honeycomb 1¼-inch thick composite material will score both 50 cal. and 106 mm rounds.

2. The sample size of 2 rounds indicate that the honeycomb material will not detonate the HEAT round. Wood structural members should be removed when firing the HEAT round.

3. Foil fold back will reduce life of skin unless improved adhesives are used.

4. The following ball ammunition target, practice, tracer or other non explosive ammunition is estimated to be scorable with this material:

.50 cal

20 mm

40 mm

76 mm

90 mm

105 mm

106 mm

120 mm

(High explosive war heads should be tested individually against skin for compatability.)

RECOMMENDATIONS:

1. Additional, larger, test samples should be obtained without wood framing (along at least 3 of its sides). Sample size of 6''X 6' would match existing 106 target size.

2. Tests of a foam plastic, or similar material, bonded to the backside of the target should be made in an effort to extend the target's useful life.

3. Similar plastic honeycomb materials with metal screen surfaces similar to chicken wire should be investigated to increase the target's useful life. The screen would reduce air resistance, an important consideration for moving target applications.

4. Future tests of target materials should include a full compliment of 106 ammunition in addition to missile type AT weapons.

Volume II

Appendix V

Operational Test and Analysis Procedures

1. Introduction

This appendix is designed as a guide for the test officer in implementing operational service tests of antitank (AT) weapon systems. Research and development in this area of Army weaponry have received considerable attention in recent years, and the efforts have generally evolved around some type of wire-guided missile system. The focus of attention has been to increase the hit probability of the weapon and the attention does rightfully belong here, but other aspects of the weapon system should also be considered. Paragraph 2 shows the pertinent measures of effectiveness (MOE) in AT weapon system analysis and references paragraphs which describe test soldiers selection and training techniques. Paragraph 3 gives the comparative analysis procedure.

2. Test Techniques and Procedures

a. Measures of Effectiveness

The measures considered important in testing antitank weapons are listed below:

Hit probability

Engagement hit probability

Miss distance

Time to first hit

Percent of basic load per hit

Vulnerability factors

Time to first round

Time to reload

Movement time

Emplacement time

Percent of targets engaged

Time to shift fire

Time to clear malfunctions

b. The procedures for applying these measures are detailed under paragraphs 4, 5 and 6 in the main body of this report. Paragraph 5 describes the test facility design which focuses on the appropriate combat actions. Paragraph 4, under objective 2, details procedures for selection and training of test soldiers and soldier to weapon assignment procedures. Paragraph 6 discusses test design, range design, instrumentation selection and analysis.

3. Comparative Analysis

a. A new weapon system has been subjected to reliability test before it is received for service test. It is assumed that in these tests the new weapon system did exhibit the desired reliability. However, the Infantry Board does have reliability as one of its areas of responsibility; and if the new weapon system is shown to be unreliable it should be rejected. This is not to say that other measures should not be gathered and analyzed, because if other indicator variables look good, decisions can better be made on expenditures to cure the reliability problem.

b. If a weapon system passed the reliability portion of a service test, the next most important consideration is whether or not the weapon system can hit the target. Note that the reliability MOE are not acceptance MOE, they are rejection MOE. It is assumed that

engineering tests have determined the probability of a kill given a hit, and if these differ for the weapon systems under test they should be merged with the hit probability estimates. The hit probability for comparative purposes will either be a first-round-hit probability or an engagement-hit probability. This may involve comparing the engagement-hit probability of one weapon system with the first-round-hit probability of another depending on the rate of fire capabilities of the competing systems. See figure V-I.

The basis for comparison will be engagement hit probability where an engagement may be comprised of single or multiple rounds. If the new weapon system is a subsonic wire-guided missile then its first-round-hit probability will be compared with the engagement-hit probability of the standard system. It is assumed that the standard weapon can fire more than one round in the same time frame that the test weapon is firing one round. The total number of engagements resulting in a hit will be divided by the total number of engagements to determine engagement hit probability. This sum will be taken over the sample size of all crews/soldiers at each firing range. The statistical treatment of the two probabilities will be no different than if one crew/soldier had fired all the rounds. However, it must be emphasized that one crew/soldier firing all the rounds is most undesirable. The number of crews/soldiers is to be determined as in paragraph (4) p. 16. Pooling data to arrive at one number makes it even more important to use adequate population representation in both numbers and characteristics. The statistical comparison will either be a chi square or t-test.

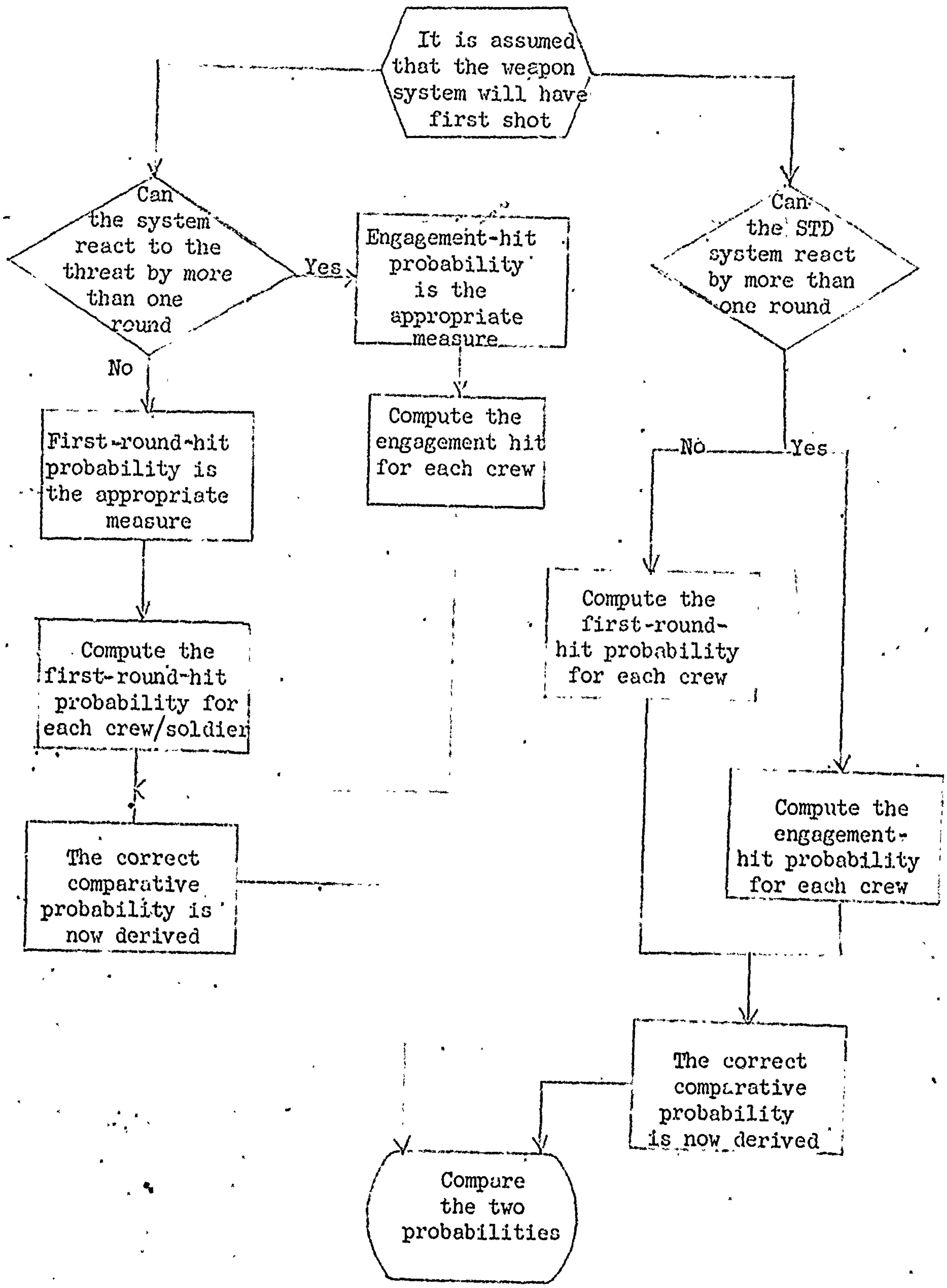

It is assumed that the weapon system will have first shot
Can the system react to the threat by more than one round
Yes
No
Engagement-hit probability is the appropriate measure
Compute the engagement hit for each crew
First-round-hit probability is the appropriate measure
Compute the first-round-hit probability for each crew/soldier
The correct comparative probability is now derived
Can the STD system react by more than one round
No
Yes
Compute the first-round-hit probability for each crew
Compute the engagement-hit probability for each crew
The correct comparative probability is now derived
Compare the two probabilities

Figure V-I

c. If a comparison of the engagement hit probability fails to produce a superior weapon then either a responsiveness or sustainability analysis is in order. Sustainability appeared to be the more appropriate measure in testing small arms, but for AT weapon systems responsiveness appears to be the better decision category. Sustainability is largely a function of the carrier, which happens to be the soldier for small arms but for antitank weapons it may be some type of vehicle. Since this is true it is felt that a test of sustainability woul tend to be more of a carrier test than a weapon test. This is not to say that sustainability should not be considered, but evaluation for this MOE is likely to be largely subjective.

The MOE that measure responsiveness are time to first round, time to first hit, time to reload, and time to shift fire. Rather than trying to separate these measures on a basis of importance another variable will be introduced which encompasses all four. This variable is time to hit and shift. A one-sided t-test will be used to analyze this variable. A t-test could be performed at each range having dual targets or an analysis of variance could be performed over all ranges.

d. The measures: miss distance, percent of basic load, vulnerability factor, movement time, emplacement time, percent of targets engaged, and time to clear malfunctions are not MOE that should be disregarded in an analysis of weapon system performance. The importance of any one measure is largely a function of the weapon system being tested and these aspects of a weapon performance should be examined for possible improvement and maybe even weapon rejection, but probably not be used as a basis for a new weapon selection.

4. Weapon system stability can be measured indirectly with time base measures. Time to hit and shift is a measure of the firer's ability to cope with recoil, hold the sights on target and relay the weapon. This measure may perhaps be too broad particularly if causes other than stability resulted in a long time measurement e.g. a long reload time for one weapon system. Time to first hit is a lower level MOE that has potential as a measure of stability. This measure would tend to measure a gunner's ability to keep a wire guided missile, in particular, on target. If sighting problems, unrelated to stability exist, then time to first round would yield the cleanest numerical measure of stability. This MOE would measure the gunner's ability to track a target. Judgement will have to enter into the MOE selection since unrelated characteristics will have to be largely a matter of expert opinion.